PACIFIC MARINE SCIENCE REPORT 72 - 5

MARINE SCIENCES (BRANCH) Directorate
PACIFIC REGION

ANNUAL REPORT 1971

ENVIRONMENT CANADA
Water Management Service
Marine Sciences Branch
Pacific Region
1230 Government St.
Victoria, B.C.

Canada

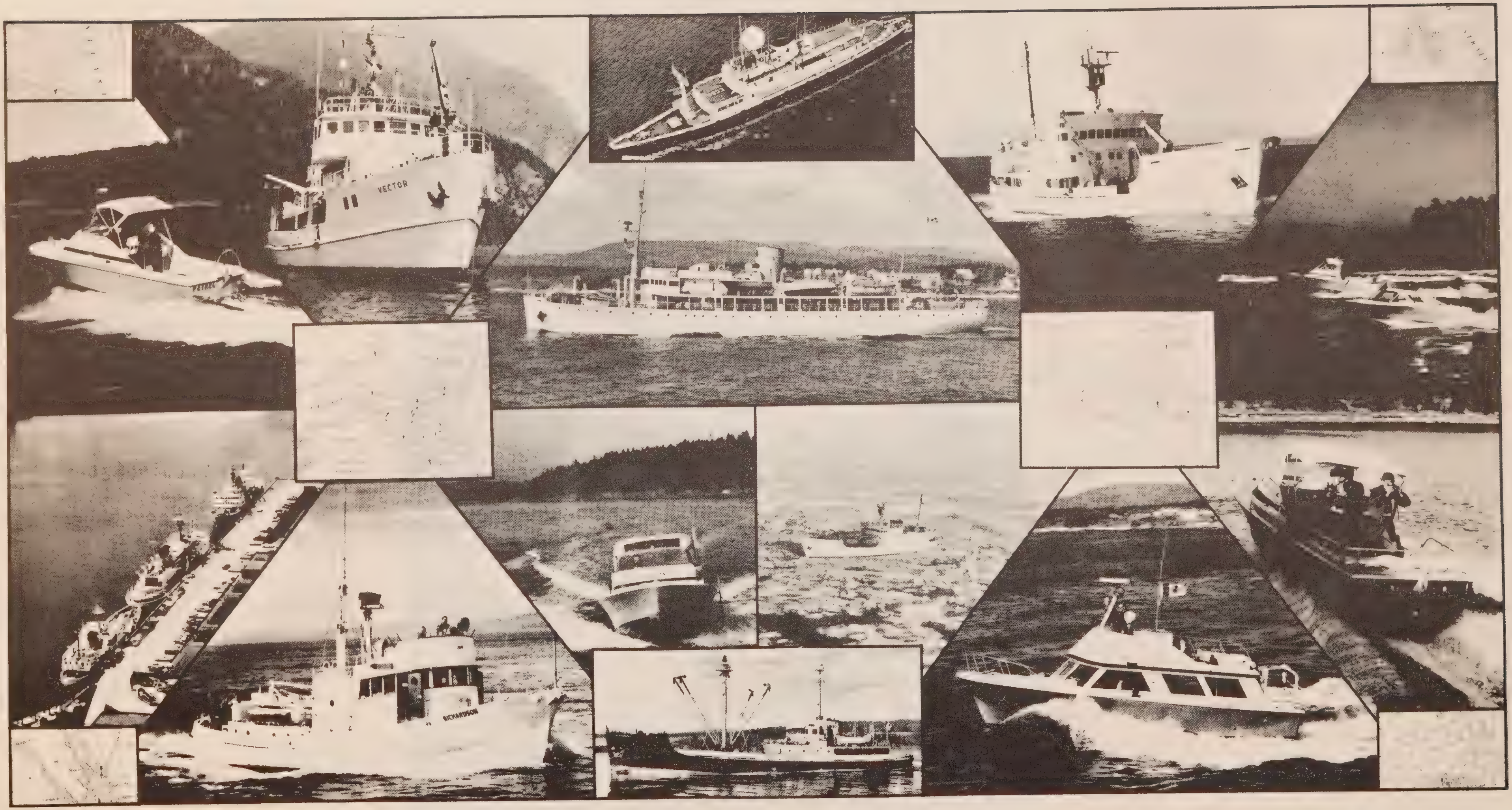
MARINE SCIENCES BRANCH

PACIFIC REGION

ANNUAL REPORT 1971

Dodd Narrows
B.C.

Victoria, March 1972.

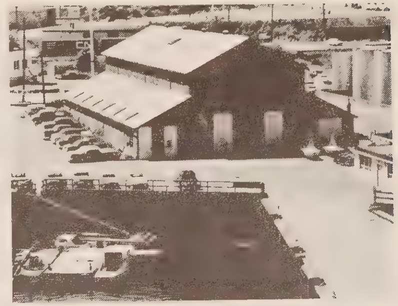


Ships and launches of the Pacific Region.

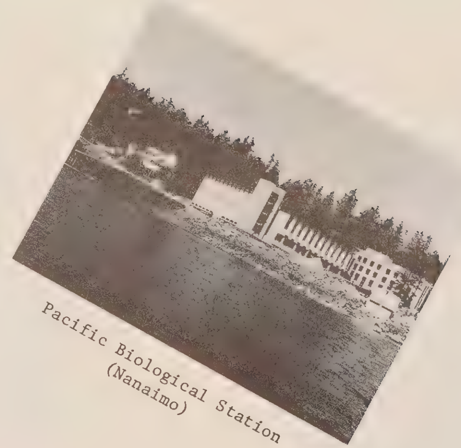
TABLE OF CONTENTS

MARINE SCIENCES BRANCH PACIFIC
LOCATIONS

Defence Research Establishment Pacific
(Esquimalt)



Canadian Hydrographic Service Depot
(Victoria)



Pacific Biological Station
(Nanaimo)

Regional Headquarters
(Victoria)

Pacific Environment Institute
(West Vancouver)

Electronics Laboratory and Oceanography Trailer
(Victoria)

Frozen Sea Research Group
(Esquimalt)

INTRODUCTION

This report for 1971 is the first annual report issued directly by the Marine Sciences Branch, Pacific Region, of Environment Canada. The initiation of an annual report series is in keeping with the significant expansion and extension of Branch activities in the Region.

Expansion of the scope of Marine Sciences activities in the Pacific Region was placed firmly in the plans of the Department of Energy, Mines and Resources from 1962, soon after the Department took on the major federal responsibility for the development of oceanography in Canada. Construction of a West Coast Oceanographic Institute was originally scheduled for the mid 1960's, but was deferred in favour of the Canada Centre for Inland Waters at Burlington. Now the long-awaited build-up on the Pacific is taking place within the framework of the new Department of the Environment.

This build-up occurs at a time when the demands upon hydrography and upon oceanography are changing and expanding rapidly. Nowhere are these new demands felt more intensely than in the Arctic and Pacific areas which are the responsibility of MSB,Pacific. The prospect of greatly increased activity in the Western Arctic and upon the Mackenzie River--and some of this increase has already taken place--requires intensification of charting activities in both areas. Canada has an announced position that the borders of national jurisdiction should be defined as the edge of the continental mass. There is a responsibility, partly hydrographic and partly geophysical, to identify the location of this boundary off Canadian shores, not least in the Pacific and in the Western Arctic.

The quantity of shipping on the west coast is increasing rapidly, new ports are being constructed and the size of vessels making use of these ports is increasing dramatically. All of this puts new demands upon hydrography. The increase in the amount of pleasure traffic--and the still larger increase which must be anticipated--demands new charts of special format covering waters of little interest to commercial shipping.

The increasing public concern with the danger of oil spills and other pollution problems requires greatly improved knowledge of the nature of current systems near our shore, currents which are both tidal and non-tidal. In oceanography the new concern for the health of the oceans with respect to pollution requires a breadth and sophistication of chemical oceanographic effort far beyond what was previously considered adequate.

New thrusts in meteorology, leading to extended range weather forecasts, seasonal forecasts and the need to understand the nature of climate so that man's impact on climate can be ascertained, all put great demands upon oceanography. It has become apparent that the behaviour of the atmosphere, for periods longer than a few days, is to very considerable extent determined by the ocean. Since at Canadian latitudes the air flows are generally towards the east, the Canadian need for information about the variability of oceanographic conditions in the eastern Pacific is great and is increasing.

The survey and research activities of the Region, which form the bulk of this report, were carried out against a backdrop of extensive organizational change. It is a great credit to the staff and to the responsible managers that so much was accomplished.

Some established links have been sundered and many new ones have been forged. The Branch is now part of the Water Management Service of the new Department of the Environment. We find ourselves in the same department as, among others, the Fisheries Service including the Fisheries Research Board, and the Atmospheric Environment Service. These changes have the advantage of bringing us into formal association with many of the groups with which we have had in the past, and will probably have even more in the future, close working associations. On the other hand our former close organizational link with those doing marine geology and geophysics has been broken, since these groups remain within the Department of Energy, Mines & Resources.

Many of the responsibilities of the new department call for co-operative action by two or more of the units within the Department. Recognizing this fact, the Directors of the various departmental units in the Region formed themselves into a Regional Directors' Committee which meets several times a year. Here action concerning such problems as determining the probable consequences of a dam on the Fraser River at Moran, and ascertaining the impact of industrial and residential development of estuaries, is initiated and coordinated. MSB,Pacific has played an active role in the development and functioning of this committee. Another facet of the intensification of inter-service activity has been our participation on numerous task forces, working groups, etc. as listed elsewhere in this report.

Within MSB, Pacific there have also been organizational changes. The operations of the Hydrographic Service continue to form the largest portion of the effort of the Branch in the Region, but the incorporation of other groups and the addition of new staff to these groups has substantially broadened our capabilities and responsibilities.

The Director, R.W. Stewart, and Deputy Director, W.N. English, who were appointed late in 1970, moved to Victoria and took up full-time activities early in the year. P.W. Nasmyth was designated Head of a new Ocean Physics Division. The remaining staff of the Fisheries Research Board Pacific Oceanographic Group at Nanaimo were transferred to the Marine Sciences Branch and joined the Branch's Oceanographic Section at the Pacific Environment Institute in West Vancouver.

The Hydrographic field staff was bolstered by the return of Mr. R.W. Sandilands from a one year appointment as Assistant Regional Hydrographer in Central Region. Mr. John Larkin was a welcome addition as

a secondment for two years from the Headquarters Training Staff. One staff member received a field assignment to Central Region while two of Central Region staff spent the summer in the Western Arctic aboard C.S.S. PARIZEAU. Such staff exchanges not only complement the natural flexibility of the Canadian Hydrographic Service but also ensure a greater inter-regional understanding.

The Hydrographic capabilities of the Region continue to strain to meet navigational requirements in Pacific Coastal Waters, the Beaufort Sea and on the Mackenzie River. Substantial progress was achieved in each of these areas. In addition the Service, in particular its Tidal Section, has provided support for oceanographic activities not only of the Branch but of other elements of the Department and of the University of British Columbia. The traditional statistics for the Hydrography Division for 1971 are as follows:

Stations built	293
Kilometers of sounding	30,602 km
Shoals examined	1,236
Area sounded	17,702 km^2
Number of bottom samples	1,143

The Ship Division has maintained its responsibility of providing ship services for the Branch and for other users of ship time supplied by the Pacific Coast Ship Pool. Ships' crews continue to constitute approximately half of the personnel in the Region.

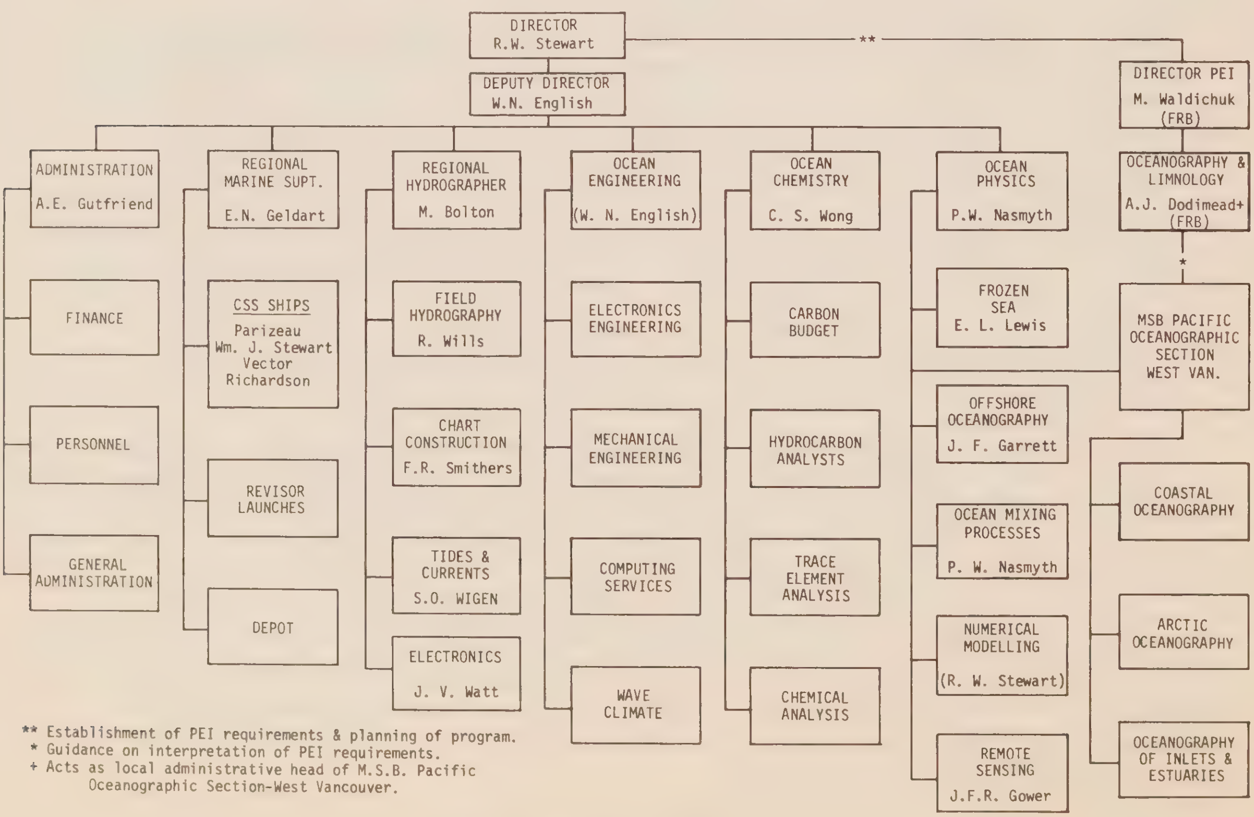
The Ocean Physics Division is spread, too thinly, over several different locations, only the Offshore Oceanography Section being accommodated in the Victoria headquarters. The Frozen Sea Research Group has its own rented accommodation in Esquimalt and also works in the Defence Research Establishment Pacific premises in the Canadian Forces Dockyard. Most of the activity of the Ocean Mixing Section is also carried out within DREP, and is conducted in close collaboration with personnel of that establishment. A substantial element of the division is located in the Pacific Environment Institute in West Vancouver, with the main responsibility of providing physical oceanographic support to P.E.I.'s pollution studies. The wide dispersal of the division continues to hamper appreciably the efficiency of its operation.

The increase in the responsibilities of the Ocean Chemistry Division, which arises in great part from the recognition of the importance of pollution studies, has lead to an authorization for this division to expand substantially. This expansion has had the usual effect, in 1971, of reducing the time available for the division to perform its functions; however, its future capability will be greatly enhanced. The division is housed at the Fisheries Research Board Pacific Biological Station in Nanaimo. The physical separation from other activities of the Branch reduces the effectiveness of inter-actions between oceanographers of different disciplines, so active measures have been taken to rehouse this group in Victoria during 1972.

Despite these difficulties a substantial number of programs showing considerable imagination and initiative are being undertaken. Except for the established time series of Station Papa and on Line P, rather little of the Branch's oceanographic effort is devoted to what might be called "traditional" oceanography. Both the demands upon and the opportunities available to oceanographers are changing rapidly and we expect this situation to continue. In hydrography, too, new techniques are being actively examined and experimented with. We expect the future to be one of rapid evolution and innovation.

While giving full weight to the importance of understanding, managing and protecting the marine environment, we have not forgotten the economic aspects of marine sciences and have done our best, under somewhat difficult circumstances, to encourage the development of Canadian marine technology. Many discussions were held during the year with West Coast companies. One licensing agreement was signed, resulting in $67,000 worth of production by a British Columbia firm, and negotiations on another instrument manufacturing project are underway.

A list of contracts is given later in the report. We have tried to contract out as much of our work as possible. The long time from initiation to contract (3 to 8 months) and the total uncertainty as to when a contract will be let, have caused embarrassment, frustration and severe delays compared to doing the work in house. We intend to persevere, but it is clear that the procedures for letting contracts must be made faster and more predictable, if the Government policy of increasing the ratio of contracts to in-house work is to be effectively implemented.



ORGANIZATION CHART

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

Pacific Region has the responsibility for the charting of all navigable waters of Western Canada and the Western Canadian Arctic, including the Athabasca-Mackenzie Waterway. The eastern limit of the region is the Alberta-Saskatchewan border. The responsibility includes not only standard field hydrography but also the measurement and processing of tidal and tidal current information. An active development group is responsible for the evaluation of new equipment and the development of techniques and systems. A small but viable electronics section ensures that all electronic equipment is functional, in addition to providing expertise to the other hydrographic elements.

The Chart Construction and Distribution Section compiles all West Coast field data and maintains the current catalogue of West Coast Charts. It is also responsible for the hand correction of all catalogued charts and the distribution of these charts to chart dealers in Western Canada and the Western United States. During the past year increased support, in the form of graphic analysis and photography, has been given to the Oceanographic Divisions.

The Sailing Directions Section was reactivated with the appointment of Mr. T. Jones from Headquarters as Sailing Directions Officer in December 1970. Since that time B.C. Pilot, Volume 1, has been rewritten in a new, simplified format and considerable progress has been made on a new small boat pilot, covering the cruising waters of the Strait of Georgia.

Our liaison with the Canadian Power Squadrons has been intensified through the introduction of the MAREP (Marine Reporting) program. Both the Chart Construction Section and Field Hydrography played major roles in ensuring that understanding and adequate feedback were established and maintained.

One innovation occurring last year was the direct involvment of the Region in the Hydrography I training program. For the first time the field phase of this basic training program for embryonic field hydrographers took place on the B.C. Coast. CSS WM. J. STEWART was the training ship, and from February through April training activities were conducted in Saanich Inlet. Although the environment did not quite compare to the Carribean setting of previous years,it permitted an adequate program and was perhaps more typical of the normal habitat of Canadian hydrographers.

During the year the Hydrographic Division participated in and was represented at the International Union of Geodesy and Geophysics in Moscow, the Institute of Navigation national meeting in Pasadena, the Canadian Institute of Surveying in Ottawa, the Canadian Hydrographers Conference in Halifax, the National Canadian Power Squadrons convention and the Pacific Northwest Oceanographers Conference, in Victoria.

FIELD HYDROGRAPHY

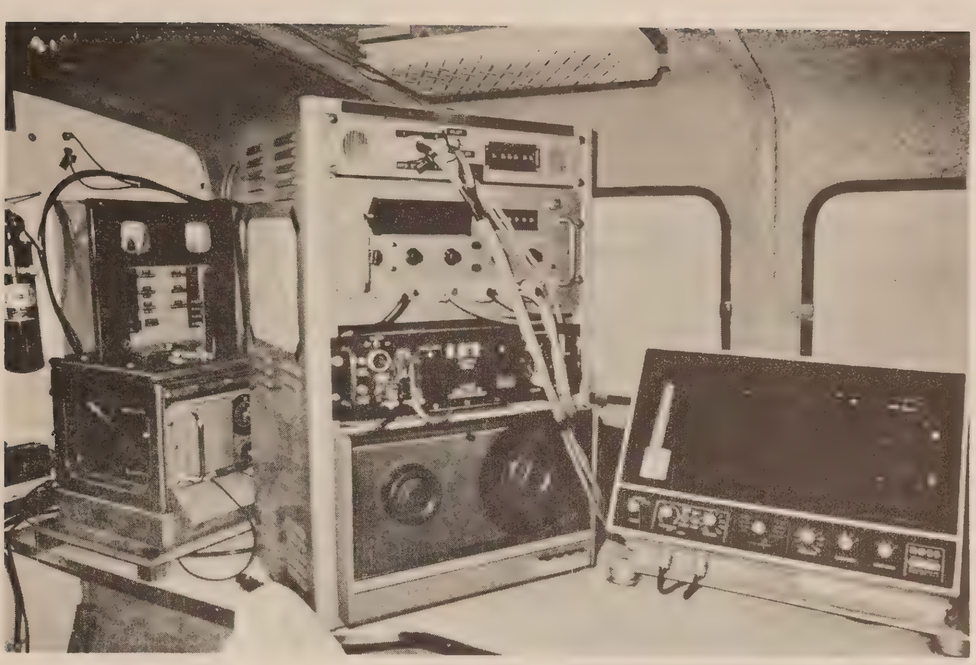
R. Wills, Regional Field Superintendent
E.B. Clarke
F.A. Coldham
G.H. Eaton
J.E.V. Goodwill
K. Highton
R.C. Hlina
W.S. Huggett
L.P. Landry
P.O. Lee
B.M. Lusk
C.G. McIntosh
A.D. O'Connor
R.A. Pierce
R.D. Popejoy
A.R. Raymond
G.E. Richardson
G.W. Rogers
R.W. Sandilands
J.A. Vosburgh
M.V. Woods
P.Y. Yee

This year hydrography from the two major vessels, WM.J. STEWART and PARIZEAU, was a continuation of the surveys commenced in 1970. The REVISOR, besides her revisory work along the south coast, carried out a survey off the southeast corner of Vancouver Island, and the RICHARDSON was retired from the Arctic and brought down to Victoria. A charter vessel, the PILOT II, carried out surveys on the Mackenzie River.

The WM.J. STEWART (under C.G. McIntosh) was employed to carry out surveys in the Strait of Georgia, Malaspina Strait, northern Chatham Sound and Dixon Entrance. These surveys were to up-date the information on the charts and bring them up to modern surveying standards. Some of the information on the charts dated back to the early British Admiralty surveys of 1910. All surveys used RPS and Hydrodist for position, and the Strait of Georgia survey used Mini-Fix in addition to the other methods. A special survey was carried out of Quatsino Narrows. This was a large scale survey of the narrows requested by Utah Construction and Mining Co. to aid in the passage of large ore carriers to their mine in Rupert Inlet. A current survey was carried out at the same time, as tidal currents in the passage exceed six knots.

The PARIZEAU (under W.S. Huggett) worked mainly in the Beaufort Sea, sounding on the continental shelf north of Tuktoyaktuk Peninsula. This was a continuation to the east of last year's survey. This area is of prime importance to the oil companies in their quest for Arctic oil, and is also known for its underwater "pingo" like structures. Positioning was by Decca Lambda, which is maintained by Computing Devices of Canada on a charter from the Polar Continental Shelf project of the Department of Energy, Mines and Resources. GEBCO soundings were taken on the way to and from the Arctic. At the request of the Northern Transportation Company Ltd. a reconnaissance survey was completed of the entrance to Eskimo Lakes.

This year two automated acquisition systems were carried, one of them, ROLAB (Ross Laboratories) was installed aboard the PARIZEAU and the other, known as HAAPS (Hydrographic Acquisition and Processing System) was installed on one of the launches. These automated acquisition systems will now be a permanent part of the hydrographer's tools. The data is processed onboard using a PDP8/E computer and Calcomp-563 plotter.



Launch portion of the Hydrographic Acquisition and Processing System (HAAPS) used to acquire bathymetric data and position fixes, in digital format, on magnetic tape.

For 1972 the Decca Lambda chain will be moved farther east with the master station at Atkinson Point and the slave stations on Baillie Island and Hooper Island. This will allow the survey of the continental shelf in the Beaufort Sea to be completed. The surveys on the continental shelf are multi-disciplined. Magnetic and geological data is also collected in conjunction with the hydrographic data.

Prior to leaving for the Arctic a shore party was established at Fanny Bay and a survey of the area between Vancouver Island and Denman and Hornby Islands south of Comox was carried out. This survey completed the re-survey of the Strait of Georgia from Comox south.

This year, for part of the time, the REVISOR (under B.M. Lusk) reviewed all charts in the Queen Charlotte Sound area. This completed a revision of all charts of the southern British Columbia Coast (Cape Caution south), which was started in 1969. The remainder of the time was spent on a conventional hydrographic survey of Juan de Fuca and Haro Straits. This survey is being conducted because of the building of a large oil refinery in the State of Washington a few miles south of the U.S.-Canada border. The refinery will primarily be using Alaskan Oil brought to the refinery by giant tankers from the Gulf of Alaska, and the wide channels of Haro Strait and Boundary Pass will become one of the main shipping routes for these tankers to and from the refinery. Consequently an energetic re-survey of the area is being carried out with particular attention being paid to depths up to thirty meters. The survey is on a large scale, 1:25,000, to ensure good coverage, and will be continued in 1972.

On the charter vessel PILOT II (under G.E. Richardson) a detailed survey was carried out on the Mackenzie River from mile 565 to mile 685, and about 322 km of reconnaissance surveys were carried out in the delta channels. This was the first year a vessel had been chartered on the Mackenzie. The work will be continued for the foreseeable future.

The Mackenzie River, though over 1600 km long, has only been surveyed and charted in detail for about 96 km, mostly at the up-stream end. The rest of the river has just been track sounded, and at such a small scale that the charts are not more than maps showing the recommended route. New surveys on the river will be done at 1:50,000. This year strip charts from Fort Simpson to Norman Wells at this scale were published, but these show only track sounding that was done in 1964. It is hoped that strip charts for the remainder of the river to Tuktoyaktuk will be available prior to the 1972 season. Although these strip charts show only track soundings, and there are large gaps in the coverage and many aids to navigation have changed, they are an excellent beginning to modern charting of the river.

Mackenzie River: This view of the Rampart Rapids at a low water stage in the fall shows one of the River's natural navigational hazards. At present only approximately 100 kilometers have been surveyed and charted in detail. Work is continuing on this project each year.

HYDROGRAPHIC DEVELOPMENT GROUP

N. M. Anderson, Head
A. R. Mortimer *
N. S. Fujino *
C. R. Tamasi *

* On "rotation" from Field Hydrography

The Hydrographic Development Group's program for 1971 included:

(1) development of the use of aerial colour photography for hydrography;
(2) writing and cataloguing computer programs for hydrographic computations;
(3) further investigations of inshore positioning systems for hydrographic and other surveys.

A field evaluation of colour photo interpretation of the northwestern shore of Georgia Strait was made. Depths were interpreted to 5.48 m, as well as high and low water lines and foreshore characteristics. A preliminary report of this evaluation has been distributed. Colour photography of the Victoria area was flown and mosaics compiled for a 1972 survey. Controlled colour photographic pairs have been supplied to the University of New Brunswick, Department of Survey Engineering,for two media contouring with their analytical plotter. Scientists doing biological and geological research have found these colour photographs to be of assistance in their projects.

Using a PDP/8, a HP 2116 and the University of Victoria's IBM 360, computer programs have been prepared to draw (1) lattices for electronic positioning systems, (2) accuracy contours for these systems and (3) coastlines. The majority of computer programs used by hydrographers have been catalogued and their input/output formats standardized.

An evaluation of the new Trisponder x-band positioning system was completed and a report prepared. Also a further evaluation of the transmission pattern of a low gain omni-directional antenna for the Motorola Range Positioning System was made to define the accuracy limitations of this antenna. A paper was given on inshore positioning systems at the International Congress of Surveyors in Germany.

SAILING DIRECTIONS SECTION

T. Jones, Head
J. W. Chivas

The projects undertaken by this section in 1971 were:

(a) compiling Supplement No. 2 to the "B.C. Pilot" (5th edition), Vol. 2;
(b) compiling Supplement No. 5 to the "B.C. Pilot (7th edition), Vol. 1;
(c) revising the "B.C. Pilot", Vol. 1, in a new format;
(d) collecting and filing material for the compilation of Sailing Direction (Pilots) to complement the new small boat charts for the Gulf area.

New material for the"B.C. Pilot", Vol. 2 involved increasing the size of the previous supplement (they are cumulative) from 11 pages to 24 pages. Much of this new material was gathered on a field trip through the Inner Passage from Vancouver to Stewart in a commercial vessel. The new material for the "B.C. Pilot", Vol. 1 increased the size of its Supplement from 70 to 107 pages.

The revision of the "B.C. Pilot", Vol. 1, is a major undertaking which will result in a virtually new publication with the title "B.C. Sailing Directions". It was undertaken because of the adoption of two new policies. The first requires that information which appears on nautical charts should not be duplicated in their complementary Sailing Directions; this involves a drastic pruning of the present 7th edition. The second policy requires that this publication will in future be printed by a computer-controlled process; this will result in the publication being reprinted annually with all new and changed information spliced into it. This process will eliminate the need for annual supplements which are heartily detested by mariners because of the laborious procedures they involve. Six of the 9 chapters which make up this volume are now in manuscript form.

A new Sailing Directions publication to complement the new small boat charts for the Gulf Islands is the result of a new policy which recognizes the need for charts and sailing directions designed to meet the requirements of the large (and growing) population of small boats on the coast of British Columbia. The collection of information for this publication involves mining an entirely new vein of ore and the preliminary samplings, i.e. questionnaires mailed to marinas, boat works, marine service stations, have already been made. It is expected that a start will be made on the manuscript of this publication early in 1972.

TIDAL AND CURRENT SECTION

S.O. Wigen - Regional Tidal Superintendent

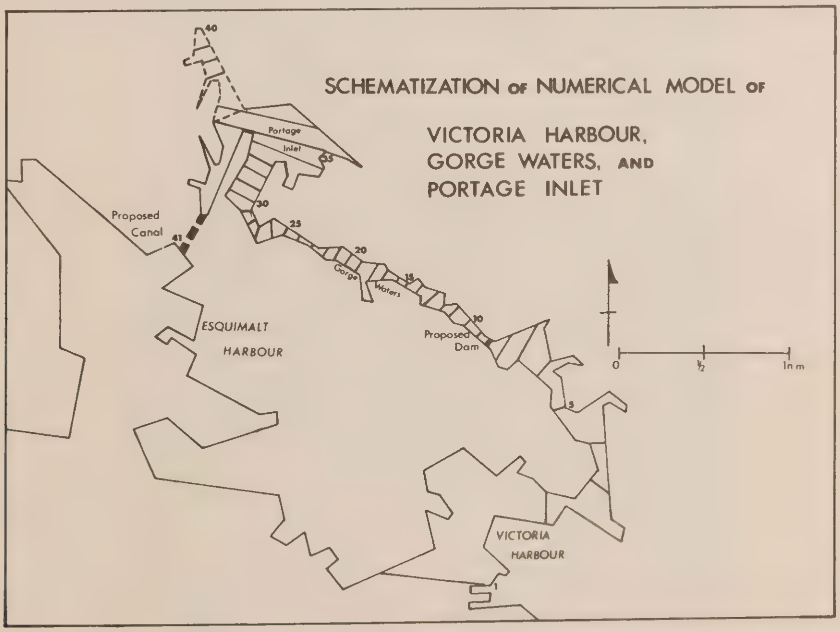
The Tidal and Current Section operates as an integral part of the Canadian Hydrographic Service. Its activities for 1971 are reported here under the four Units of the Section.

Hydraulic Research

A.B. Ages
A.N. Douglas

A one-dimensional explicit numerical model was developed of Victoria Harbour, Gorge Waterway, and Portage Inlet. The model examined the effect of a proposed dam between Victoria Harbour and the Gorge upon the tidal behaviour in the Harbour. It also examined the feasibility of a canal between Portage Inlet and Esquimalt Harbour. The model was calibrated by field measurements of tides and currents and was completed in September.

In the second half of 1971 salinity and temperature measurements were carried out in the Fraser Delta, to study the behaviour of the saline wedge in the Fraser Main Arm and North Arm. The results of these field measurements are to be incorporated in a numerical model of the Delta, which was developed earlier. Additional tests are to be carried out in 1972.



Site of proposed dam on Gorge Waters and canal between Portage Inlet and Esquimalt Harbour. Effects on tidal behaviour in Victoria Harbour have been examined by numerical model.

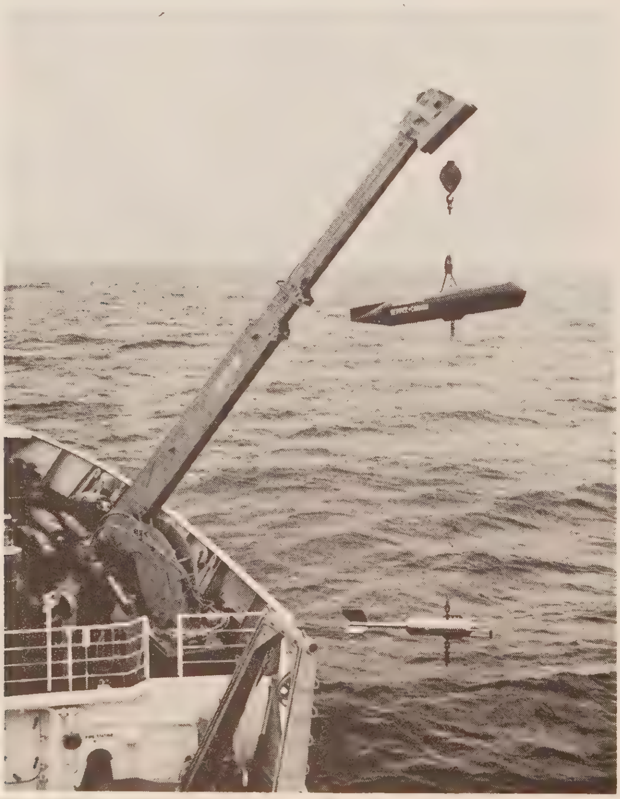
Current Surveys

J.F. Bath
W.J. Harris

F.V. Hermiston
K. Highton

A tidal and current survey of Alberni Inlet was carried out in the period February to May, 1971. Current meters were placed at seven channel sections for one-month periods to define the principal circulation, with 40 metering stations being occupied. CMDR Neyrpic current meters used for the survey had an operating efficiency of 70%. All meters were recovered-one requiring the services of the submersible "Pisces" when a release mechanism malfunctioned. Drift float observations supplemented the surface measurements.

Recording tide gauges were installed at 11 locations, to define both tidal elevations and seiche waves during the survey. The Alberni Inlet program was carried out in very close co-operation with a research project of the Institute of Oceanography at U.B.C., in which wind and fresh water impounding and discharge were correlated. C.S.S. "Parizeau" and later C.S.S. "Vector" were used. Each week three or four different participants in the Hydrography I Staff Training Program were on board. They did drift-poling in Sproat Narrows, serviced tide gauges, stood a Savonius current meter watch, saw CMDR current meters serviced and were instructed in Satellite Navigation by the Radio Officer.



The Canadian made CMDR NEYRPIC current meter, being used to record current speed and direction in Strait of Georgia survey.

Aanalysis of the current meter records is nearing completion and the results are scheduled for publication in Data Record of Current Observations for Alberni Inlet Volumes VII and VIII.

In conjunction with the Hydrographic Charting of Quatsino Narrows, C.S.S."William J. Stewart" carried out a program of current observations there. Drift floats were tracked for a 3-week period, and the velocities have been correlated with head differences between tide gauges operating at the ends of the Narrows. Flow patterns and velocities before and after slack water are being compiled in a report to aid Pilots in navigating ore-carrying freighters through Quatsino Narrows.

Two current meter stations have been established in the Victoria area, one in Baynes Channel, and the other south of Race Rocks. Up to one year of data is being sought in each location, to form the basis for a new primary current reference station for predictions in Pacific Coast Tide and Current Tables. Some troubles have occurred with the tow lines of tug boats cutting the moorings or dragging the meters out of position. However, initial records have been obtained for harmonic analysis, and the program is continuing into 1972.

Current observations obtained in recent years throughout the Gulf Islands are being compiled, in order to produce a current atlas as an aid to navigation. Additional field measurements needed to complete the atlas are being scheduled for 1972.

Analysis and compilation of the current meter data obtained from major surveys through the Strait of Georgia in 1967 to 1970 are well advanced, and a Data Record will be published.

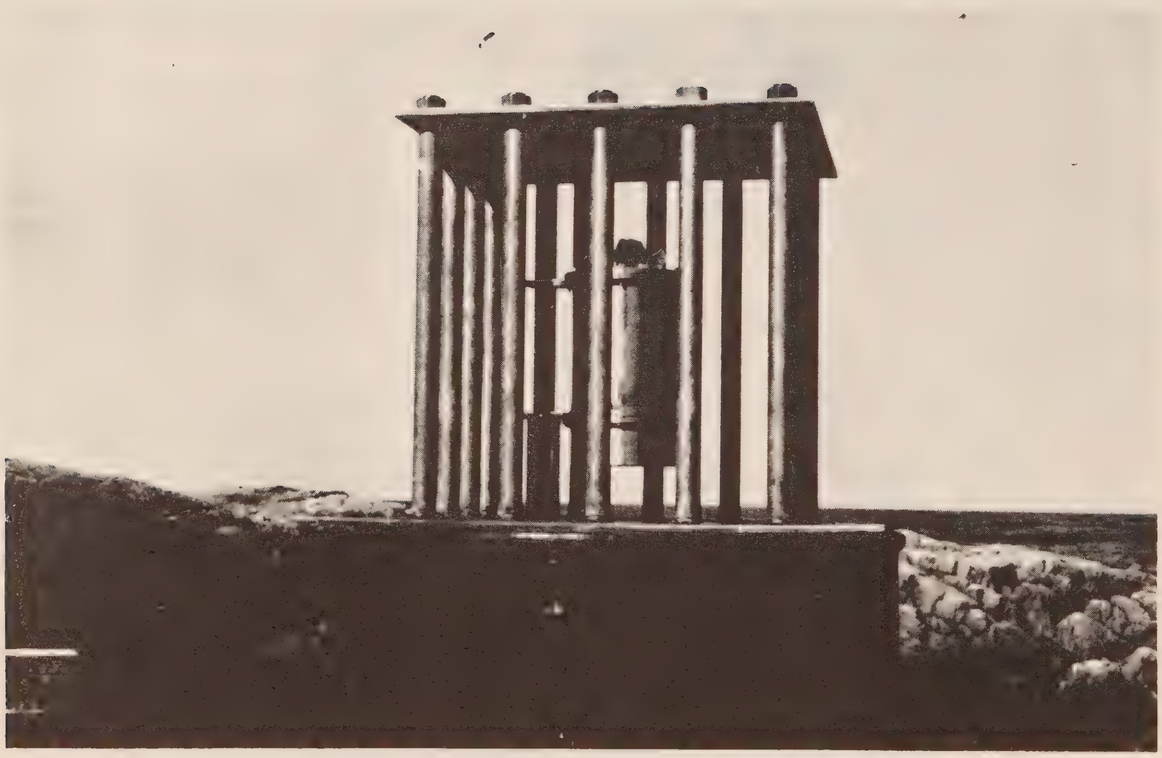
Tidal Survey

W.J. Rapatz
R.E. Brown

This Unit was given the responsibility of arriving at a realistic low water datum in the Mackenzie River for hydrographic charting purposes. Two bubbler gauges were operated in the Mackenzie, and the records from these gauges, combined with the records from gauges operated by Water Survey of Canada, were used to establish charting datums from Great Slave Lake to Fort Good Hope, a distance of about 1,100 km. Preliminary datums were established from Fort Good Hope to the Delta, subject to more information in future years.

Gauge stations were operated at 7 locations in Juan de Fuca and Georgia Straits,continuing the tidal, current, and physical oceanographic study which commenced in 1967. Co-tidal charts of this system are being prepared for publication, and a preliminary draft was supplied to Dr. P. Crean, who has developed a two-dimensional model of the Straits for his thesis at the University of Liverpool.

Teleannouncing tide gauge stations at Steveston and New Westminster were maintained in operation to assist navigation in the Fraser River. The gauges are monitored daily to ensure their accuracy. The teleannouncing gauge at Tofino, which is part of the Tsunami Warning System for the Pacific, was transferred to a new permanent site constructed by Water Survey of Canada. At Langara Island the gauge station was reconstructed. Some problems in the transducers and in the radio transmission have been experienced at this isolated site, but it is hoped that during 1972 the station can become a new and important link in the Tsunami Warning Net.



Transducer for Langara Island teleannouncing tide gauge, mounted in new stainless steel cage.

Tidal Survey continued to provide a variety of essential services. Hydrographic field parties for the Pacific and western Arctic Regions were supplied with gauging equipment and vertical control data. Tidal and current information for Hydrographic charts were constantly updated. Recent tidal analyses were reviewed for revision of the Secondary Port listing in Tide and Current Tables. Tidal and current information for the B.C. Pilot is being rewritten. Each day brings a wide variety of requests for information from mariners and boat operators, scientists or consulting engineers, and the public.

Helicopter support, provided by Polar Continental Shelf Base at Tuktoyaktuk for tidal survey of Eskimo Lakes, N.W.T.

Data Processing

B. Stenning
L. Ponse

The Data Processing Unit processed all Marine Sciences Branch tide records for the Pacific and western Arctic regions, and forwarded the data to Ottawa for analysis and inclusion in "Water Levels Volume 3". All records were submitted in the form of punch cards ready for computer processing, and consisted of hourly tide heights, high and low water times and heights, and monthly extreme tides.

The Unit performed other support services, keypunching computer programs and a variety of data, and verifying all Chart Distribution keypunching.

A large backlog of current meter data from 1969 and 1970 current surveys in the Strait of Georgia, and from 1970 and 1971 current surveys in Alberni Inlet, were translated into vectors and placed on magnetic tape with the Tidal and Current Section's Hewlett Packard computer. After considerable editing Alberni Inlet data were processed at the University of Victoria to produce speed-direction diagrams, daily residuals and harmonic constants. During 1971 the Section's computer capability was increased, with the acquisition of an 80-column Versatix matrix line printer, and a 9-track magnetic tape unit to interface with the Hewlett Packard 2116 B computer.

In May the Section was connected to the Computer Sciences of Canada Ltd. time sharing system with an ASR33 model teleprinter as our terminal.

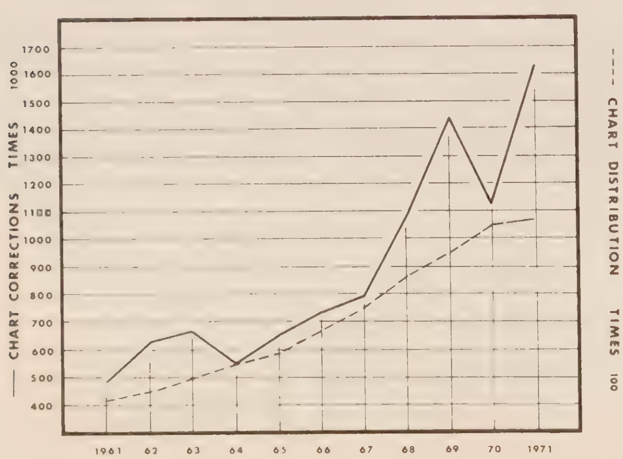
CHART CONSTRUCTION

F.R. Smithers, Head
R. Banyard
R.D. Bell
P.C. Browning
D.J. Clark
J.H. Coldwell
E.M. Colter
D.G. Dobson
K.R. Holman
A.G. Lyon
T.M. Mani
C.J. Nast
M.M. Patton
T.C. Plume
M.S. Taylor
L.G. Thomson
V.N. Young

This Section is responsible for the compilation, revision, correction and distribution of the Pacific Region charts and publications. In addition, illustration drafting, photographic and printing services are provided for the Region.

The primary activities of the Section have been to compile new charts from new surveys, revise existing charts from new information, hand correct published chart stock from Notices to Mariners and distribute these charts to the public.

During 1971 Chart 3400 was compiled at a scale of 1:160,000 and Chart 3310 at 1:40,000. The first Pacific Region small craft chart, which is in 4 strips covering an area from Victoria to Nanaimo and including the waters of the Gulf Islands, has also been compiled. Prince Rupert Harbour, Chart 3701, and Venn Passage, Chart 3703, have been scribed and are in the final stage of checking. A total of 14 other charts were revised for new editions, most of the information being obtained as a result of field revisory surveys.



The number of charts corrected and distributed has continued to grow. The dip in corrections in 1970 was caused by a temporary move of the Section.

A total of 107,777 charts were distributed from the office during the year. These charts required 1,269,715 hand amendments in order that they become updated prior to distribution. Over 17,000 copies of nautical publications including Tide Tables, B.C. Pilots, Light Lists and Radio Aids were also distributed.

There are 161 chart dealers on and around the Pacific Coast and, of these, 34 were inspected in 1971. Inspection takes the form of certification of all stock and the cancelling of outdated charts. Because they failed to meet dealer standards, 12 dealerships were cancelled. Eighteen new applicants were granted dealerships.

Nautical chart displays were manned in Seattle and Vancouver. The section compiled all land and bathymetric contours for a relief model of the Strait of Georgia at a scale of 1:80,000. This large model will be displayed by the Department of the Environment in the 1972 Vancouver Boat Show and later at other public shows.

SURVEY ELECTRONICS

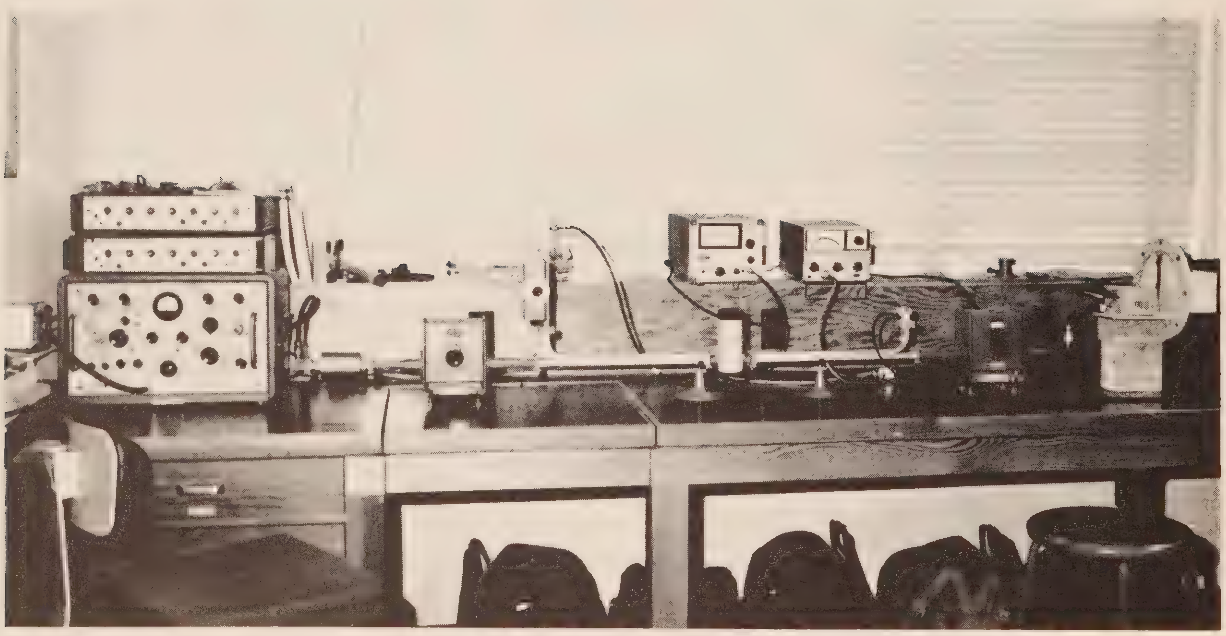
J.V. Watt, Head	W.R. Taylor
C.F. Ryan	J.S. Wallace
J.S. Rainko	T.J. Soutar

The primary task of the electronics group is to provide maintenance, installation and repair services as dictated by the Hydrographic and Ships Division requirements. The group's secondary task involves the provision of engineering and technical advice and services to various groups within the region. These services include interfacing, design modifications and the design and construction of new equipment.

Maintenance, repair and calibration services are provided for the wide variety of electronic equipment and systems in use aboard the Region's four major ships and twenty launches, at the Region's Electronics Laboratory, in the field, and at sea. The various equipments serviced include HF and VHF Communications Equipment, Sonar and Echo Sounder Systems, Ships Radar and Navigation Systems, Precise Positioning Systems, Data Acquisition Systems, Computers and Computer Peripherals. The maintenance requirements have increased significantly in the past year with the acquisition of a complete data logging system and a PDP 8/e computer processing system. Other equipment additions include a second Motorola Range Positioning System (R.P.S.) and an increase in the number of echo sounder and radio telephone units.

The major changes brought about in the area of maintenance during this past year involved the calibration of echo sounders and the maintenance of the R.P.S. A re-evaluation and subsequent alteration in techniques employed in the calibration of echo sounders and a major effort to improve and standardize maintenance procedures applied to the R.P.S. were undertaken.

Design projects involving the group over the past year include the design and construction, in association with others, of the hardware and software required to interface a Ross Laboratories Data Acquisition System to the M.S.B. PDP 8/e to produce a system capable of plotting bathymetry on-line. Other projects involved the design and construction of an interface board for operation of the C-Tech depth digitizer with a Ross 400 Fine Line recorder and the redesign and construction of a Bedford Institute designed LPD 111 Matching Unit to allow operation of the BIODAL System with an LPD 401 digitizer unit. Modifications, in accordance with Bedford Institute specifications, were completed this year on the Alpine "PESR" Sounder Recorders to permit operation of these units under control of the BIODAL digital clock.



Test Equipment set-up as applied in the tuning of the Motorola Range Positioning System (R.P.S.) X-Band Radar Transponders.

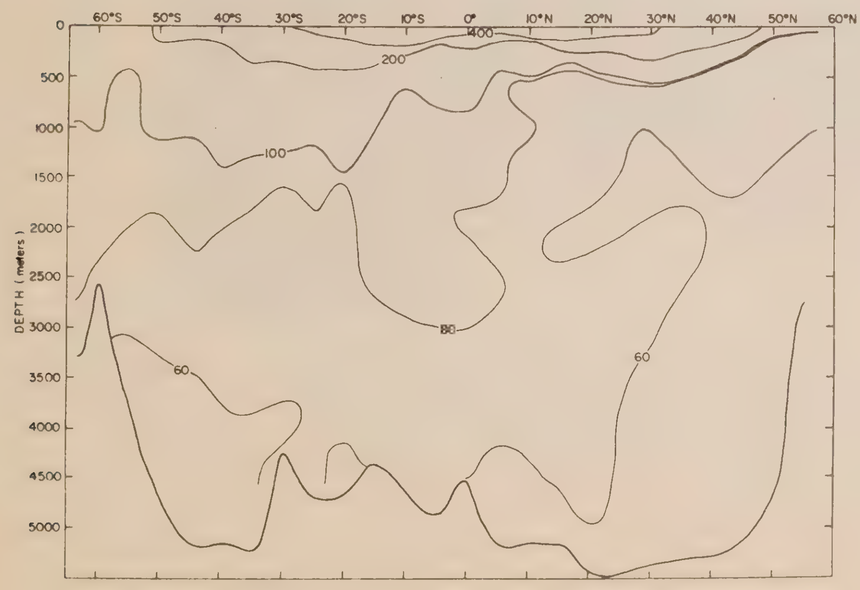
OCEAN CHEMISTRY DIVISION

C.S. Wong, Head
R.D. Bellegay
P. Vandergugten

The main activity of the Division of Ocean Chemistry in 1971 was on setting up the organization: this included defining our direction of research, recruiting technical and scientific staff and planning the budgetary and space requirements. Facilities were being acquired to equip 65 m^2 of laboratory space (radiocarbon dating) in B.C. Research and about 195 m^2 of office, storage and laboratory space (oceanographic, carbon dioxide, trace element and hydrocarbon laboratories) in the MSB Depot in Victoria. Limited by the small size of the staff and the heavy administrative duties associated with the early stages of development of a newly set-up division, the scientific activities could only be focussed on processing the HUDSON-70 data for publication and station "P" chemical data for a review and adjustment of on-going weathership chemical program.

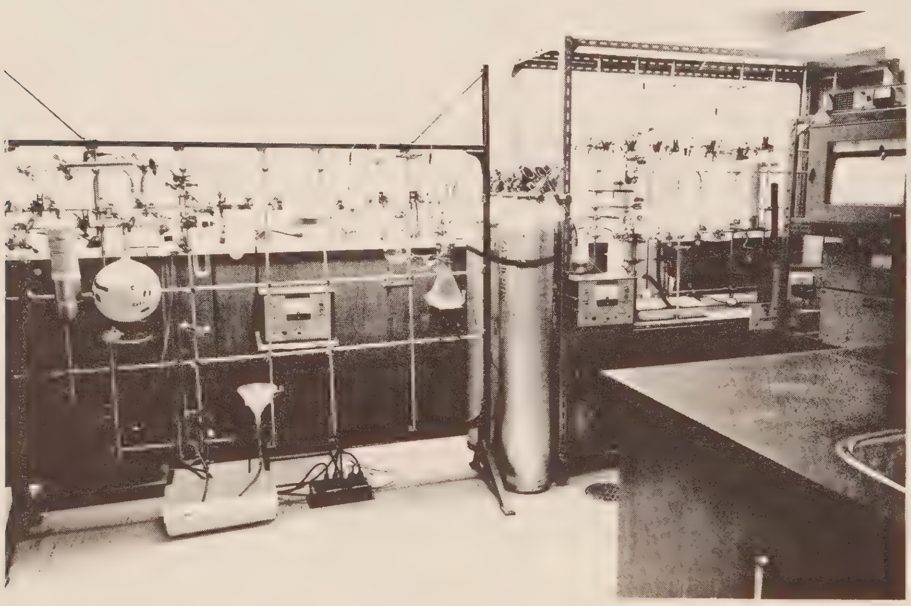
HUDSON-70 data. IMB-1130 programs to calculate carbonate chemistry parameters from thermodynamic relations were written to process the shipboard potentiometric titration data. A paper is being prepared on the alkalinity and another on the saturation depth of calcium carbonate in the Pacific Ocean. The dissolution of calium carbonate is a major geochemical problem. It is important in the buffering mechanism of the ocean, which, as is discussed below, influences atmospheric CO_2. Our calculation of the degree of saturation of calcium carbonate in the Pacific shows that a larger volume of the ocean is undersaturated than previously thought.

Nutrient Chemistry. Daily collection of sea water samples in the surface layer at station "P" was made for auto-analyses of phosphorous, nitrogen and silicon to meet the requirements of F.R.B. and other biological users of station "P" data, and to supply background information for other programs, such as the marine carbon budget study.



DEGREE OF SATURATION OF CALCIUM CARBONATE IN THE PACIFIC ALONG 150°W based on thermodynamic relations and HUDSON-70 alkalinity and total CO_2 data. The 100% line separating the upper supersaturated water from the lower undersaturated water, is about 1000 m. deep in the southern hemisphere and less than 500 m in the north.

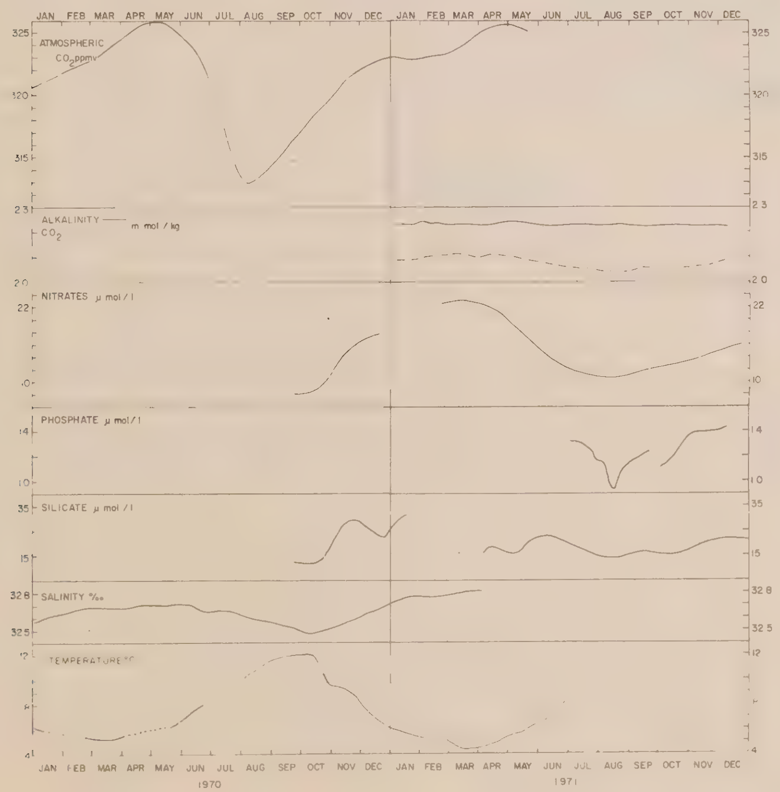
Marine Carbon Dioxide Budget. Concern about the atmospheric CO_2 increase and its possible climatic effects has brought about an expansion of interest in the study of this subject from the geophysical field into the environmental area. To date, the quantitative aspects of the atmospheric CO_2, such as the seasonal variation, long-term upward trend and year-to-year variation in the rate of increase, have been reasonably well established through the efforts of Keeling's group at the Scripps Institute of Oceanography in the U. S. A., and of Bolin's group at the Meteorological Institute in Sweden. There is a crucial lack of knowledge of the role of the ocean. Is there a year-to-year change in the ocean's capacity to absorb atmospheric CO_2? Which factor is most important in controlling the air-sea exchange coefficient: turbulence, the marine biosphere, or the carbonate chemistry? Is there a seasonal change in the air-sea exchange rate? Answers to these questions are needed critically in formulating any successful predictive model of future atmospheric CO_2. The manning of the Canadian weathership at ocean station "P" (50°N, 145°W) has offered us a unique strategic advantage in embarking on a major chemical oceanographic effort on such a long-term study of a significant environmental problem.



INFRA-RED GAS ANALYZING SYSTEM for atmospheric CO_2 and oceanic CO_2, with a precision of ± 0.1 ppm. is the only high precision CO_2 monitoring system in Canada.

In 1971, an exploratory study of the oceanic CO_2 system was made at station "P" using potentiometric titration techniques to obtain alkalinity and total CO_2 from $HgCl_2$- preserved samples. In the chemical data processed so far, the alkalinity is surprisingly constant while the oceanic total CO_2 changes by about 2% in an annual cycle. The atmospheric CO_2, oceanic total CO_2 and nutrients in surface waters show an annual cycle with winter maximum and summer minimum. These observations suggest that the marine biosphere may play a more important role than has previously been thought, relative to the buffering capacity of the sea water in regulating the atmospheric CO_2 budget at station "P". Our effort in 1972 will be expanded to start a time-series on partial pressure of oceanic CO_2 and air-sea C14 exchange at station "P".

Much of the work done in 1971 was devoted to instrumentation: (a) radiocarbon dating facilities to be set up in B.C. Research, (b) construction of two p_{CO_2} equilibrating systems and (c) an infra-red gas analyzing system set up already in Nanaimo. About half-a-year was spent on setting up (c) and its subsequent testing, and its precision achieved is about ±0.1 p.m. through inter-calibration of reference tank gases with Scripps. This precision is comparable to similar systems at SIO, NCAR and the Swedish Meteorological Institute and our atmospheric CO_2 values will be tied to this global network for consistency and inter-comparison of results. Our system will be used for shore-laboratory analysis of atmospheric CO_2 extracted from surface water samples collected at station "P" and from other cruises.



TIME SERIES OF CHEMICAL DATA AT STATION "P". Weekly observations of atmospheric CO_2, oceanic total CO_2 observed at 3-day intervals and daily nutrients show an annual cycle with winter maximum and summer minimum. On the other hand alkalinity, observed at 3-day intervals, is essentially invariant. This suggests a possible significant role of the marine biosphere in regulating atmoshperic CO_2 and oceanic CO_2.

OCEAN PHYSICS DIVISION

P. W. Nasmyth, Head

The Ocean Physics Division has a total of 35 full time continuing scientific and technical personnel in four locations in and around Victoria, and including a group of 11 at the Fisheries Research Board's Pacific Environment Institute in West Vancouver. The program of the division covers a wide variety of subjects in physical oceanography and ice physics, with activities ranging from the coastal waters of British Columbia to the offshore waters of the northeast Pacific and Gulf of Alaska and the Canadian Arctic Archipelago.

The work at the MSB Pacific Oceanographic Section, attached to PEI in West Vancouver, is an integral part of the Region's program, but that section, as a major responsibility, provides physical oceanographic support for the Fisheries Service projects on pollution problems undertaken by PEI.

A study has been undertaken by contract of the application of "remote sensing" techniques in oceanography and hydrography as they may now or in the future, affect the activities of the Marine Sciences Branch.

The activities of the different elements of the Division are reported separately.

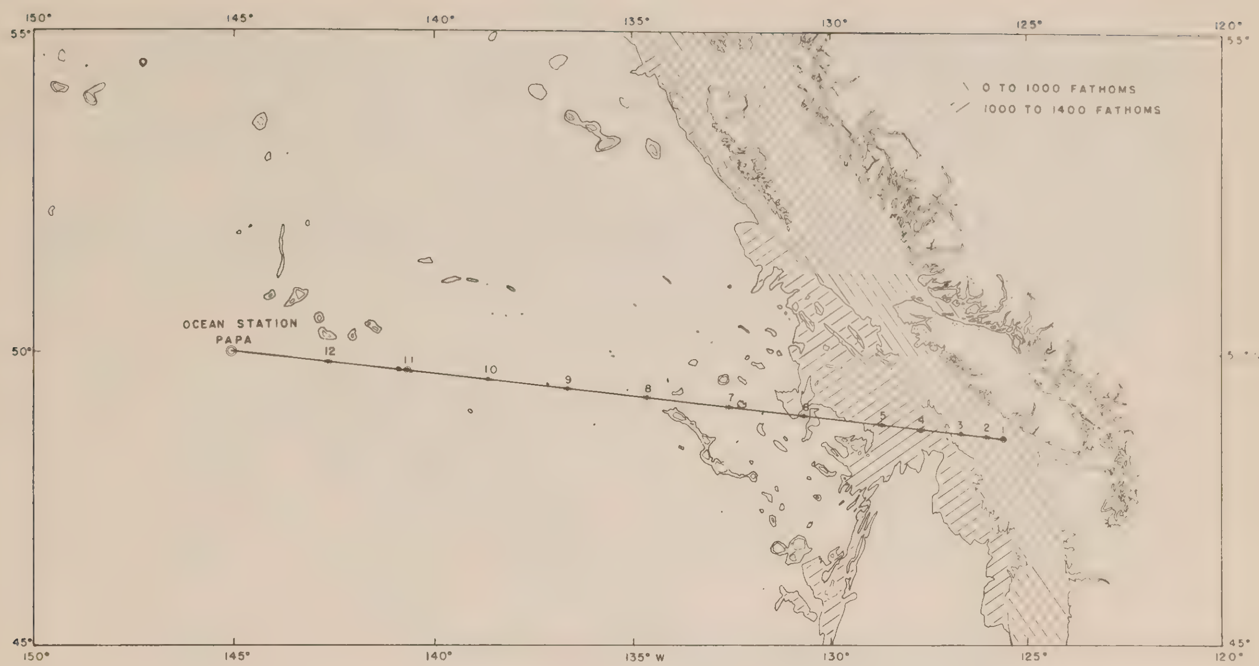
OFFSHORE OCEANOGRAPHY SECTION

J.F. Garrett, Head
S. Tabata *
R.E. Thomson *
D. Healey #
D.B. Smith
K.A. Abbott-Smith
C. de Jong
B.G. Minkley
W. Hansen *

* joined during 1971
# left during 1971

The group is responsible for the study of oceanic water motions and modifications to ocean water properties arising from physical processes with emphasis on those regions and processes affecting Canada's Pacific and Arctic coasts. Following are capsule descriptions of our major undertakings during 1971.

Weathership Oceanography. The oceanographic time series started in 1956 at Ocean Station P (50°N, 145°W), which includes weekly water samples from 27 levels between the surface and bottom, twice weekly STD casts and various other biological and chemical sampling, and the "Line P" series of 12 stations between Esquimalt and Ocean Station P, were continued during 1971. Personnel from Offshore Oceanography manned six patrols and technicians from Ocean Chemistry two, leaving only one of the nine weathership patrols without an oceanographer aboard.



LINE P, SEA MOUNT RIDGE AND CONTINENTAL SHELF

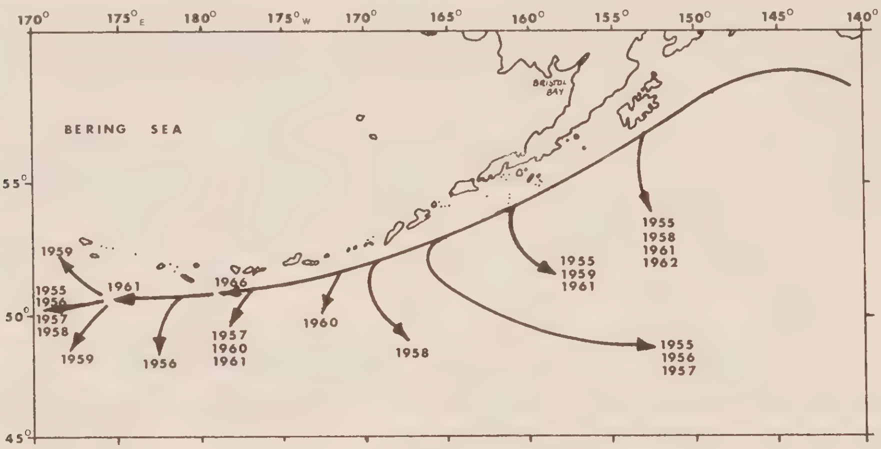
Line P stations 1 to 12 at which oceanographic observations are made to and from Ocean Station P.

The bottom topography, as indicated by the shading of depths less than 2500 m, may be the cause of increased variability in the surface water properties in the eastern half of Line P due to trapping of Rossby-topographic waves between the sea mount ridge and the coast.

One purpose of this program is to monitor variations in water properties and other indicators both to get an idea of the naturally present variability and to detect unusual events. Another is to provide data for the study of relationships between various quantities such as sea bird populations and water properties or as background for samples which are only occasionally taken, such as the mid-water trawling carried out in 1969 and 1971 by Dr. C. Gruchy of the National Museum. To enable investigators in other institutions to take advantage of this work, all oceanographic data is published and distributed in the form of manuscript reports. Six new volumes were added to this series in 1971, bringing the total to 50. In addition substantial progress was made in developing a computer accessible magnetic tape archive of all observed data to simplify the preparation of statistical summaries. (Garrett).

Ocean Climate Fluctuations. Various attempts to account for warm and cold years in the North East Pacific have been made in the past. The latest, which relates the distribution of wind stress curl to the strength of the Alaska gyre, shows encouraging qualitative agreement with the data available. However, in spite of the fact that the North East Pacific has been the subject of more systematic survey cruises than almost any other oceanic area, quantitative comparisons are still almost impossible because of the shortage of suitable oceanographic data. (Thomson).

Alaska Stream Separation. The Alaska Stream offers a unique example of a western boundary current following a boundary (the Aleutian Arc) along which the Coriolis parameter decreases at first as the boundary tends south and then increases as the boundary turns north. A linear theoretical analysis shows that the point of separation of the stream from the boundary is controlled by a balance between the local input of vorticity by the winds and the rate of loss of vorticity to the boundary in the zonal region of the coast. This seems to be supported by the limited data available. (Thomson).



ALASKA STREAM

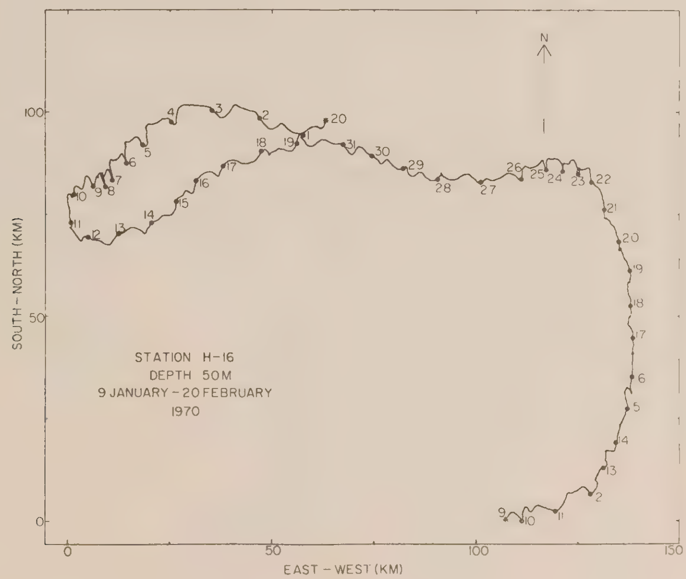
Locations at which surface salinity distributions have indicated southward branching from the Alaska Stream in various years. A new analysis of the dynamics of this flow indicates that the point of separation is controlled by the distribution of winds over the Gulf of Alaska.

Planetary Waves and Fluctuating Geostrophic Currents. Water temperatures at a depth of 3 meters along the eastern half of Line P seem to show a wave-like motion which is persistent in time, as was first noticed by Fofonoff and Tabata in 1966. As this half of Line P lies over a deep water basin between the continental shelf and a sea mount ridge, one suggested explanation was that these long period motions could be due to planetary waves trapped in this basin by the sea mount ridge. Theoretical calculations show that the majority of energy associated with barotropic planetary waves having eastward group velocity (towards the B.C. coast) is reflected by the ridge if the wavelength is less than about 2000 km, while the majority of energy of waves with westward group velocity is reflected if wavelength is less than 4000 km. The ridge therefore is more penetrable for waves of a given scale generated to its west than to its east. Also, an initially eastward propagating wave passing over the ridge could be trapped after it was reflected from the B.C. coast.

This leads to an expectation that the amount of energy associated with such waves--which have the character of variable current systems--will be greater on the east side compared to that on the west side.

A new analysis has been done using sea surface temperatures in the vicinity of Line P obtained from ship intakes to see if the apparent large variability over the basin persists when more data is used. These new statistics indicate that it does, but that it is not so striking as in the earlier data. (Thomson).

Variability of Current Velocity and Water Temperature in the Strait of Georgia. In 1969, while the investigator was employed by the Pacific Oceanographic Group, Fisheries Research Board of Canada in Nanaimo, B.C. he embarked on a program of current velocity observations in the Strait of Georgia with the primary objective of obtaining data with sufficiently high frequency and of sufficient length to examine the spectrum of the variability of current velocities in the frequency band between 1 cycle and 10^{-3} cycle per hour (period of an hour to few months) at a representative area of the central Strait. Such data are expected to provide, in addition to basic scientific information, solid background material that would be useful in a variety of applied oceanographic studies associated with pollution and fisheries.



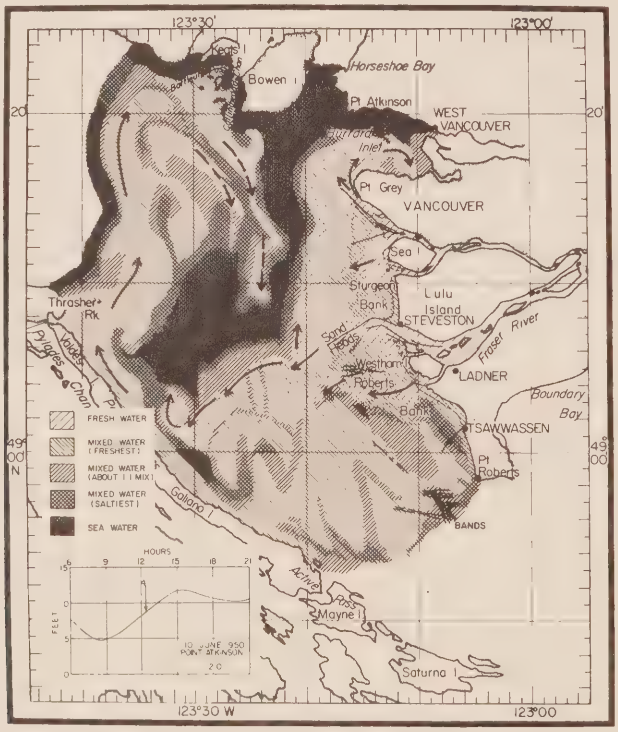
An example of current velocity obtained at 15-minute intervals for a period of 6 weeks at 50m-depth in the middle of the Strait of Georgia. Tidal currents are evident as noted in the zig-zag presentation in the line but appreciable non-tidal currents occur. During the first few days the currents flow eastward, then for the next 10 days they flow northward, followed by 19 days of westerly flow; a reversal in the current directions occurs and the currents flow eastward for the next 9 days. This example shows the importance of long series of measurements particularly in applied problems such as when information is sought for the proper selection of sewerage outfalls.

The data collected over one year during April 1969 through September 1970 in a line of 3 stations between Valdes Island and Point Grey have been processed to the point that they are available in summarized form and in detailed recorded format. Detailed analysis of the data has not begun but it is planned to compute spectra for each set of measurements

(3 weeks to 6 weeks length each), compute cross spectra for each pair of sets of measurements to examine the coherence in the data, and to examine spectra of the lower wind velocities, as well as barometric pressures and sea level heights in the vicinity (offshore as well as inshore). (Tabata)

The Movement of Fraser River-influenced surface water in the Strait of Georgia as deduced from a series of aerial photographs. Two decades ago an aerial survey along the eastern side of the central Strait of Georgia was made to aid the interpretation of surface water movements therein so that the information could be used to assist the Greater Vancouver Sewage and Drainage District in selecting a proper site for their effluent discharge. An attempt to exploit further the information contained in the series of photographs has been made, in view of the fact that the movement of water in the area has become more important in recent years.

Analysis of the data is completed and a suitable report is being prepared. One of the principal results of the analysis has been the detection of the Fraser River plume which flows as a concentrated jet toward the Gulf Island, veers to flow northeastward, as far as Bowen Island, then further veers to flow southward. (Tabata).



FRASER RIVER PLUME

An example of surface water movement deduced from a series of aerial photographs. Note the presence of a well-defined Fraser River jet emanating from the mouth of the main arm of the Fraser River. The jet-like plume extends to the vicinity of Galiano Island and appears to continue northeastward forming a clockwise "loop" that carries the river water as far northward as Bowen Island and then veers to the south. The arrow on the tidal curve indicates the state of the tide at which this movement pattern occurred.

<u>EOLE Buoy Experiment</u>. This experiment, in which Offshore Oceanography is cooperating with the Laboratoire de Météorologie Dynamique of the French Centre National de la Recherche Scientifique, is intended to study the variations in ocean surface currents over distances of a few kilometers by means of drifting buoys which will be tracked from the EOLE satellite. Ten buoys are to be launched near the end of January 1972 at about 40°N, 150°W in two clusters of five buoys each. Within each cluster the buoys are to be separated by about 1 kilometer, while the clusters will be separated by 60 km. The buoys were assembled and tested electronically by an engineer and technicians from France during December in the Marine Sciences Branch Depot. (Garrett).

C.N.R.S. (France) drift buoys being readied for sea in Marine Sciences Branch Warehouse in Victoria, B.C. Ten buoys are to be set out in the North Pacific and tracked by means of the EOLE satellite.

<u>Coastal Dynamics</u>. A tongue of relatively warm water appears annually off the B.C. Coast, but its northward extent varies greatly from year to year. A possible explanation has been found in variations in the onshore Ekman transport and the relative warmth of the upper oceanic layer in winter. (Thomson).

OCEANOGRAPHIC SECTION, WEST VANCOUVER

W.M. Cameron - Senior Research Associate

A.J. Dodimead (FRB) - Acting Head
P.B. Crean - educational leave

L.F. Giovando	J.H. Meikle
W.H. Bell	R.H. Bigham
R.H. Herlinveaux	K.A. Gantzer
H.J. Hollister	R.E. Forbes
J.A. Stickland	

The Marine Sciences Branch Pacific Oceanographic Section West Vancouver has as a major responsibility the provision of physical oceanographic support to the environmental studies of the Fisheries Service Pacific Environment Institute. Program planning and direction is done from Marine Sciences Branch Pacific Region Victoria while Mr. A.J. Dodimead (FRB) acts as head of the section for communication and local management.

Dr. W.M. Cameron is located with the Section where he conducts research under the general direction of the Director MSB Pacific Region.

Phosphate Studies. Wollenweider (1968) has demonstrated statistically that the degree of eutrophication in lakes is related to the phosphate input per unit area and the lake depth. This demonstration was heavily relied upon by the International Joint Commission in recommending a reduction in phosphate input into Lakes Erie and Ontario. The causal relationship has been a mystery to the lay public and a quantitative explanation has not been available to limnologists. It has been shown, by making gross simplifications of the phytoplankton reaction to nutrient supply, that Wollenweider's relationship can be derived from kinematic considerations. The over-simplification has been criticized by reviewers and a more refined model of this process has been explored.

Until the present, there has been no satisfactory method of predicting the phosphate concentration in a lake in relation to a change in phosphate input. A simple model to suggest this relationship was developed in 1968 and the possibility of an unexpectedly rapid response to change in supply was apparent. The model has now been extended to include seven parameters bearing on this response rate and their effect in various combinations is being investigated. (Cameron).

Arctic Studies. Recent requirement for more thorough examination of Arctic oceanographic data have led to a proposed collaboration with R.H. Herlinveaux. It is intended that the two of us prepare an oceanographic atlas of the Arctic summarizing graphically all presently available data and make an attempt to describe the processes which affect the oceanographic variables. The research program will involve the examination first of those regions in which the data are most numerous both in space and time. The features and their variation will be reported and attempts will be made to deduce the probable range of variation which might be expected. (Cameron).

Strait of Georgia. In conjunction with S. Tabata, an examination of the current regime in the immediate vicinity of the Iona Island sewerage outfall, servicing Vancouver, B.C. has been completed. In the absence of wind, surface currents were generally between ½ and 1 knot. The surface movement was predominantly northward in a narrow (approx. 3 km wide) strip immediately offshore. Seaward of this, overall southerly movement was indicated to persist, at least for periods of a few days. Thus, contrary to general belief, a net northerly flow does not exist at all times within the eastern half of the Strait of Georgia.

Aerial photograph showing Fraser River Plume, delineated here by bands of lighter coloured water.

Also, there is some evidence of a surface "microcirculation" which can at times move effluent from the sewerage channel onshore north of the neighbouring impermeable jetty (which was constructed to prevent such movement). The sub-surface motion a few kilometers offshore is mostly easterly but sometimes northerly, speeds generally being between 0.1 and 0.5 knots. The study demonstrates that detailed knowledge of the flow at all depths within the area is still meagre. It is also generally indicated that effluent from the outfall can (albeit in a diluted form) move onto the shore of Burrard Inlet and southern Howe Sound. (Giovando).

Current data in the general area suggested for an outfall in the Five Finger Island area--to service a proposed expansion of the Nanaimo, B.C. sewerage-processing system--have been obtained and are being analyzed. It appears that the subsurface net movement, both at the outfall "site" and somewhat to seaward, is strongly easterly in direction, over periods of about 6 to 7 weeks at least. The motion is generally somewhat south of east; if the flow persists in this fashion to the east of the sampling sites, it could impinge upon western Gabriola Island. Some north-of-east motion is also apparent. Fundamental diurnal or semi-diurnal tidal effects are not strongly in evidence. The average net flow is of the order of 15 to 20 km per day over a 6 to 7 week period. However, short periods (of a few days duration) featured by very restricted net movement can occur. Surface net movement, although somewhat more irregular in its major features, also appears to be easterly in direction. (Giovando).

A general survey was undertaken of problems relating to thermal effluents discharged into coastal waters, and a program of temperature and current measurements is underway in Burrard Inlet, adjacent to an existing thermal-electric generating plant. A mathematical model is being developed for studying the dispersion of various contaminants and tracers.

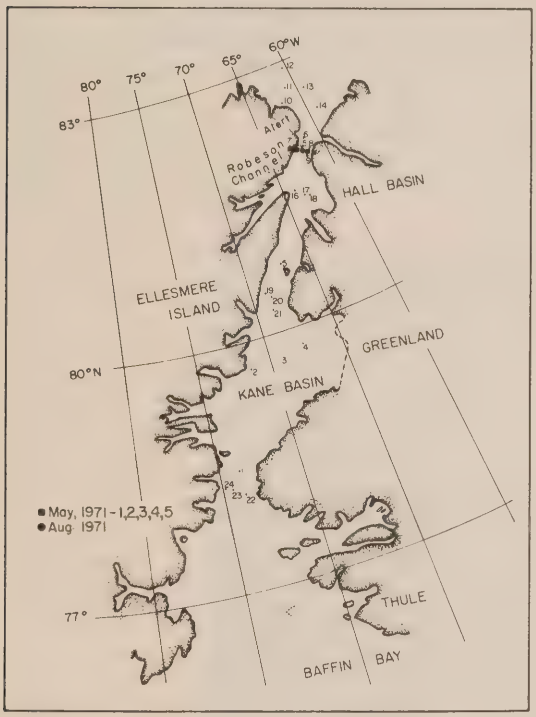
A program of measurements has been initiated to examine the physical oceanographic features of Howe Sound, a fiord-type estuary adjoining the Strait of Georgia. Two current-metering buoy arrays have been established there, and a series of line and anchor stations will be taken. Near-shore currents at PEI are also being studied. (Bell).

Daily surface oceanographic observations. Again in 1971, daily surface observations of temperature and density were made at high tide at 17 shore stations (mainly MOT lightstations) along the British Columbia coast. During the first 6 months, the monthly mean sea temperatures were generally below normal, sometimes considerably below. Below normal temperatures again became noticeable during the last 3 months, especially in December. In general, monthly mean salinities were near normal during 1971. The several instances of abnormal means were more frequently below normal but there was no regional coherence in their occurrence. (Hollister).

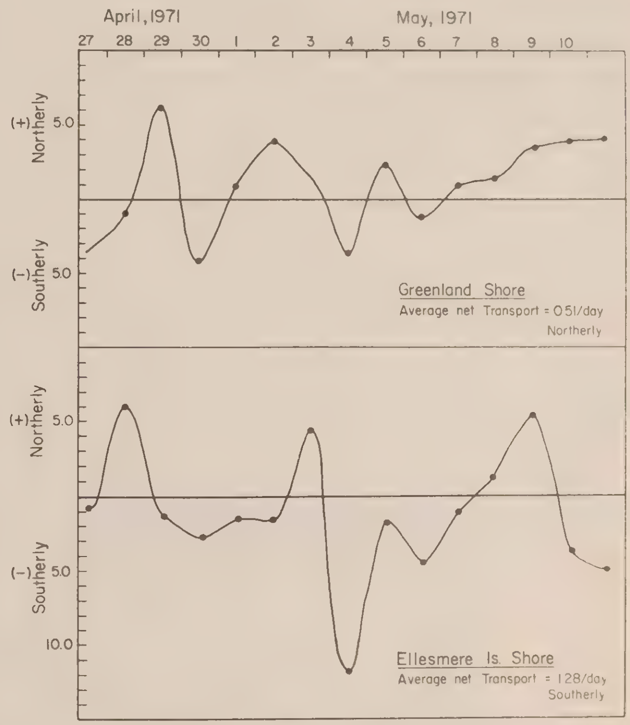
Estuarine Oceanography. Studies on estuarine circulation and mechanisms were continued in Alberni Inlet. A year of continuous observations of currents, water temperatures and winds was completed in June 1971. There data were collected to determine the resident time of surface waters and for heat budget studies. Analysis of the current data from Port Alberni harbour shows that the computed daily net transport varies both in magnitude and direction. The net movement in mid-channel was "inward"; the net movement on the harbour (east) side, was "outward". The magnitude of the net movement fluctuates seasonally, with maximum in May/June and a minimum in November/December. (Herlinveaux).

Arctic Oceanography. Oceanographic programs were carried out during both spring and summer 1971, in the channels between Greenland and Ellesmere Island. The spring program (April/May) consisted of a 15-day series of current measurements on each side of Robeson Channel and included periodic current-profile and time-series observations at mid-channel. Oceanographic stations were also taken across the channel in the same area.

The summer program (August) consisted of longitudinal and cross-channel sections of oceanographic stations from Baffin Bay into the Lincoln Sea, observed from CCGS LOUIS ST. LAURENT. The Robeson Channel cross-sections taken in the spring were repeated.



Location of 1971 oceanographic observations in channels connecting Arctic Ocean and Baffin Bay.



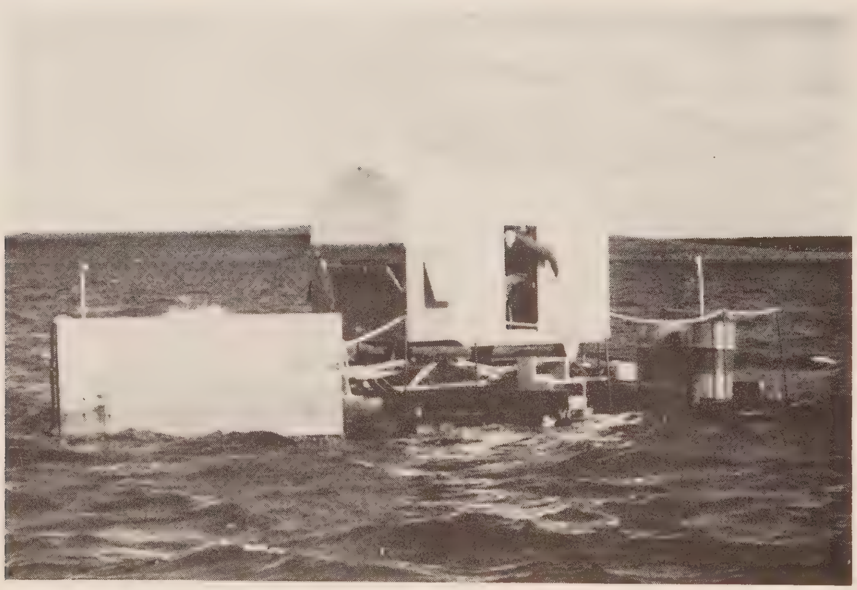
Net transports in Robeson Channel based on current measurement in April and May 1971.

Robeson Channel. Currents at 5-meters depth in Robeson Channel are markedly rotary. The average net transport for the 15-day period on the east side of the channel was 0.82 km per day to the north while on the west it was 2 km per day to the south. Because of the ice cover (average thickness of 2 m) the cause of the oscillatory nature or the movement is not considered to be related to local winds; it is possibly due to the passage of weather systems to the north and south of Robeson Channel. Further analysis of these systems and of sea-level data collected at Alert and stations to the south, will be carried out.

The vertical current profiles observed under the ice at mid-channel suggest that surface movement observed on either side of the channel may be representative of movement to depths of 50 meters (the bottom of the upper zone) or even deeper.

Baffin Bay - Lincoln Sea. Tentative results show that there are cloud-like movements of water in the column which can be identified by maxima and minima in the temperature structure. The surface salinity distribution suggests that low-salinity water, resulting from local run-off, moves north along the Greenland shore and south on the west side and in mid-channel. Ships' drift in mid-channel was observed to be about 1 knot southerly. Analyses of the data are being compiled for publication.

A hydrographic sounding program was carried out through the area as the ship proceeded to the Lincoln Sea and on the return. The sounding tracks and records were turned over to the Hydrographic Service. (Herlinveaux).



Frozen Sea Research Group oceanographic sled on the raft in Cambridge Bay. (Sept. 1971).

OCEAN MIXING SECTION

P.W. Nasmyth, Head	G.W. Chase
A.E. Gargett	R.C. Teichrob

The long term objective of the Ocean Mixing program is to develop our knowledge and understanding of turbulent mixing, in both coastal waters and deep ocean areas to the extent that we can calculate rates of transport and dispersion and attempt quantitative predictions. The factors to be predicted are the vertical transports of heat and energy and their effects on energy interchange with the atmosphere at the sea surface; and the transport and dispersion of either pollutants, nutrients or other contaminants of interest to marine ecologists.

It was reported a year ago that major responsibility for the Ocean Mixing program had been taken over from the Defence Research Board during 1970. DRB continues to support the program by contributing ship time, computer services and some of the facilities and highly developed engineering skills of DREP. A profitable overlap and interchange of personnel between this program and the DREP Fluid Dynamics Group also continues.

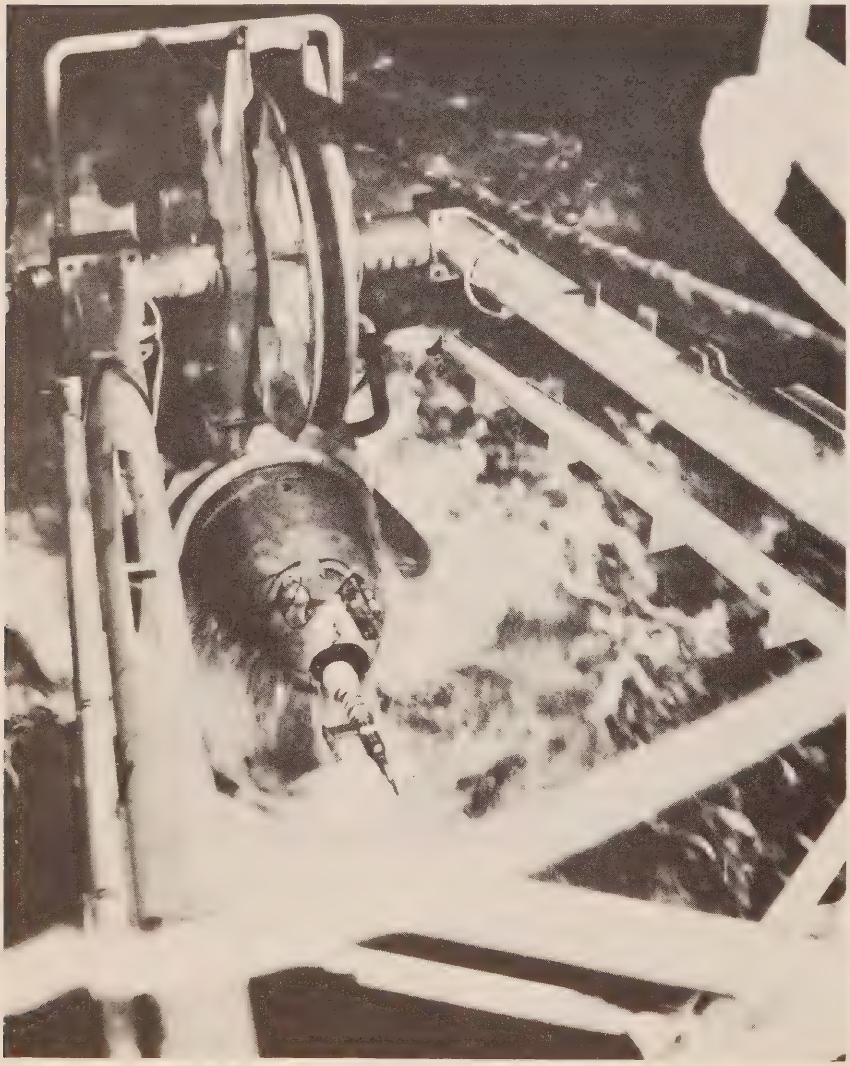
The major effort during the year has been in the development of instrumentation and equipment for a major sea operation scheduled for early 1972. The basis of the measuring system will remain essentially similar to what has been used in the past. A submerged body, towed from a surface ship, carries an array of sensors to measure temperature, velocity and electrical conductivity of the water, and fluctuations of these parameters with high resolution in time and space. Platinum film probes for temperature and velocity have a frequency response extending beyond 1 KHz and at the usual towing speed of about 150 cm per second can resolve features down to 2 or 3 mm in size. Three auxiliary temperature sensors with slower response (up to about 50 Hz) are arranged in a vertical array to obtain information on the mean temperature gradient.

A new conductivity sensor, designed for this operation, looks promising at this time, but has not yet been subjected to exhaustive tests. An array of platinum electrodes measure the conductivity of a 6 mm cube of water and a thermistor just outside the cube measures temperature. Response of the device has not yet been determined precisely, but a spatial resolution of 3 cm or better should be possible. With a faster temperature sensor, salinity determination to a resolution of 1 cm should be possible. Broad band noise level is equivalent to about 4×10^{-4} $^{o}/oo$ in salinity but long term stability has not yet been determined.

The velocity probe is extremely sensitive to vibration generated within the towed body or transmitted down the towing cable. Several isolation devices have been tried in the past with varying degrees of success. A new device has now been designed and although exhaustive tests have not yet been carried out, it appears to offer the best performance yet achieved.

The other major innovation this year has been a digital recording system. Information from the various sensors has previously been recorded on 14 channels of analogue tape of which selected portions have later been digitized for analysis. The new system offers convenience in processing as well as better dynamic range and, using two tape decks, the ability to obtain continuous records with no break for changing tapes.

The forthcoming operations in January-February 1972 will be carried out in the region southwest of Cape Flattery and out as far as Cobb Seamount. There is reason to expect that this experiment will add substantially to our still meager store of knowledge on turbulent mixing in the open ocean. (Nasmyth).



THE TOWED BODY USED IN OCEAN MIXING STUDIES shown during launching at night. The body diameter is 80 cm. Temperature and velocity probes are located side by side at extreme forward end of central spar, and the new conductivity cell can be seen a few centimeters behind and offset to the left. The towing cable with continuous rubber fairing leads to a servo-controlled winch which permits level towing to 300 m, or a repetitive vertical excursion usually 15 m above and below a preset depth.

FROZEN SEA RESEARCH GROUP

E.L. Lewis, Head	S.W. Moorhouse
J.D. Bradbury	R.G. Perkin
R.A. Lake	D.L. Richards
A.E. Moody	R.B. Sudar
K. Fujino (visiting scientist, Sapporo, Japan)	J.A. Sutherland
	E.R. Walker

During March and April, 1971 a field operation was conducted from our Greely Fiord base (80° 36' N., 79° 35' W.). Measurements of oceanographic conditions were made along the length of the fiord and, in addition, simultaneously at two locations in the fiord in an attempt to understand water movement and the flushing action of tides. Observations of dye puffs injected immediately below the growing ice sheet showed that the current reversed at a depth of one meter. These studies of circulation in an Arctic fiord system are related to an understanding of pollutant dispersion. In the same context a study of runoff in Arctic regions has been completed in order to estimate the annual fresh water input in the fiord. We consider that we are now able to obtain temperature and salinity measurements at known limits of accuracy during the Arctic winter and spring with the Guildline C.T.D. system. This has incorporated a study of experimental work by the National Research Council on the electrical conductivity of seawater very close to freezing point.

Preliminary experiments were conducted on the freezing point of seawater samples collected immediately below the growing ice sheet in order to ascertain whether there was a significant effect due to the potentially different ionic concentrations of salts in the water at that location.

Starting in August, 1971 a series of field operations were undertaken in Cambridge Bay, N.W.T. (105° W., 69° N.). To date two of the four planned operations have been completed. We wish to obtain a complete picture of seasonal variations in surface water structure associated with the growth and decay of sea ice. The precise measurement of salinity and temperature should also enable us to select between a number of models that have been proposed for the vertical mixing associated with salt rejected by sea ice during growth.

A complete oceanographic sled was mounted on a 10,000 pound cedar raft anchored in Cambridge Bay in order to make measurements during the late summer and fall. The raft was frozen into the ice and the sled pulled off it in order to make subsequent measurements through the ice sheet. We have manufactured an under-ice traversing probe to record horizontal variations in temperature and salinity beneath growing sea ice. This instrument will be deployed in Cambridge Bay in February, 1972 in an attempt to discover whether salt rejection processes at the growing interface that have been observed in the laboratory also take place in nature where conditions are not so stable and the depth of water below the sea ice is effectively unlimited. Knowledge of these

processes will aid in understanding the dispersion of any pollutants such as oil that might become mixed in with the ice.

Dr. K. Fujino, visiting scientist from the Institute of Low Temperature Science, Sapporo, Japan, arrived in August 1971 for a two-year stay. He is presently involved in a series of laboratory experiments taking samples of fresh water and seawater across the freezing point. Anomalous behaviour close to freezing is presently receiving intense study.

We are also involved with the Tidal Section in developing an Arctic tide gauge using some of the latest electronic techniques.

Greely Fiord Base (80° 36' N., 79° 35' W.) from the air.

REMOTE SENSING

J.F.R. Gower (under contract)

Most oceanographic work is in a way "remote sensing", but the expression usually refers to 'sensing' such a photography, thermal or microwave radiometry with which scientists study the earth's surface from an aircraft or a satellite.

Today, thanks to recent technological developments, an oceanographer can make an increasing variety of measurements from an aircraft, and so study properties of the ocean that change over time and distance scales that make ship measurements difficult or impossible. In the near future an oceanographer may be able to use a satellite to follow the behaviour of an entire ocean.

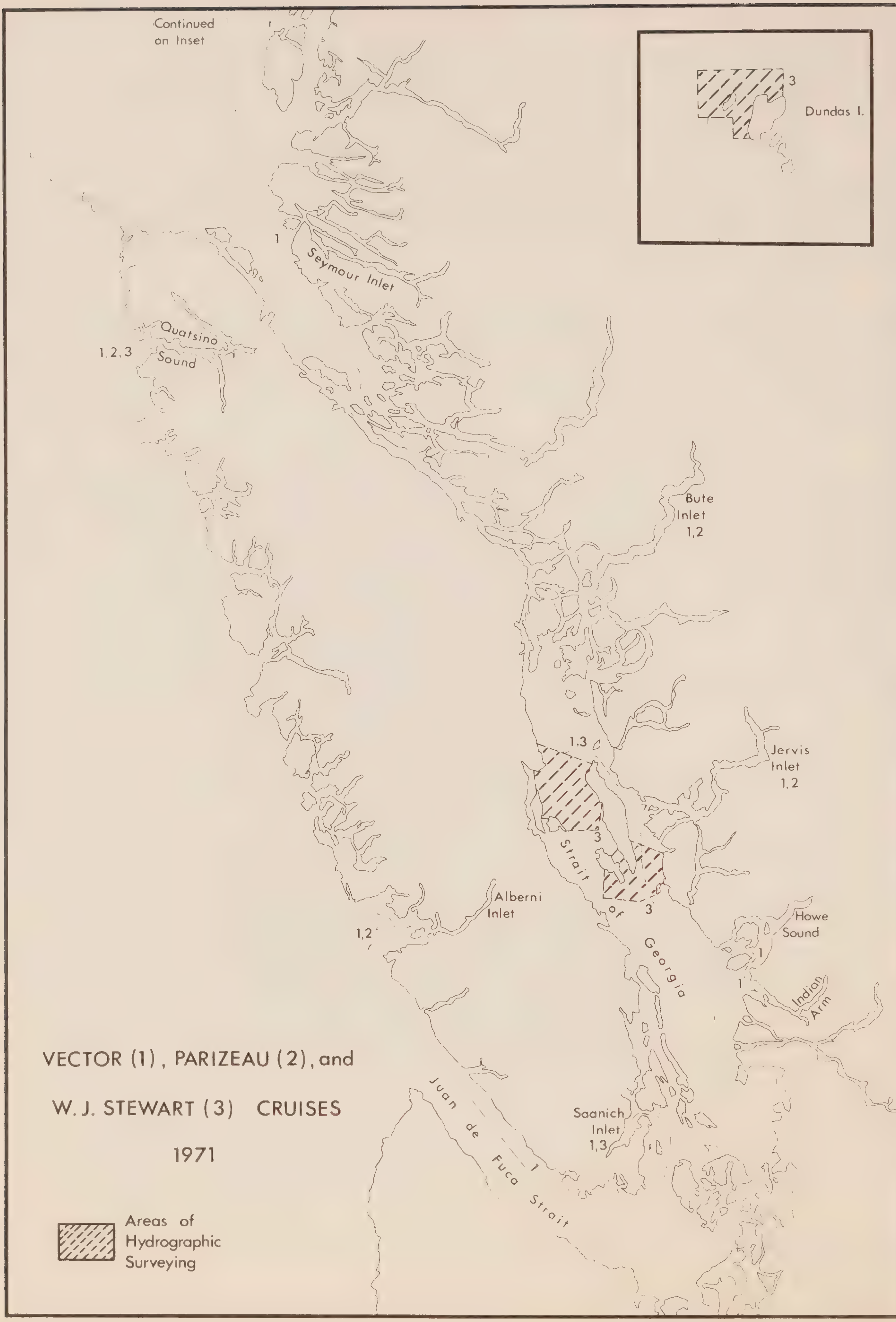
Since September 1971 I have been studying the developments in remote sensing techniques and equipment that may be applicable to oceanography. As well as the large number of papers in this field published each year, the proceedings of the symposia on "remote sensing of the environment" held at the University of Michigan is a useful indication of current capabilities and developments. About 20% of the work discussed at these symposia is relevant to Oceanography. NASA, in conjunction with the US Navy Oceanographic Office, is working on a spacecraft oceanography project and the annual reports on this work show what may be possible using measurements from space. I am preparing a survey of this literature as an internal report in the Marine Sciences Branch.

In 1971 I visited the Bedford Institute of Oceanography, the Institute of Oceanography at UBC, the Canadian Centre for Remote Sensing and Oregon State University for discussions on oceanographic remote sensing.

The most interesting currently operational techniques for oceanographic remote sensing are probably the laser profilometer for measuring wave height, the airborne radiation thermometer and airdroppable instruments for measuring temperature. Other techniques under development include pulsed laser (lidar) measurements of shallow water depth, accurate colourimetry for depth measurement and water body identification and microwave techniques for measuring roughness and possibly currents. An aircraft can also make measurements in the atmosphere near the sea surface.

Negotiations with the Department of National Defence have been underway in Victoria since November 1971 for use of a Tracker aircraft. In an initial program for 1972 I plan to use the aircraft's doppler navigator for investigating surface currents, and to make air turbulence measurements in conjunction with Dr. Miyake at UBC. Later we would want to use either the Tracker or a similar sized aircraft to carry wave height and temperature measuring equipment and an inertial navigation system.

I have also started work on a simple, shore-based, doppler radar to study radar/sea wave reasonance effects. (Gower).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VECTOR (1), PARIZEAU (2), and
W. J. STEWART (3) CRUISES
1971
Juan de Fuca Strait
1
Saanich
Inlet
1,3
Areas of
Hydrographic
Surveying

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent
F.S. Green - Assistant Marine Superintendent

1971 marked a successful year for Pacific Region ships in the fulfillment of all scheduled requirements. Since this is our first separate annual report the characteristics of each ship is given followed by a resume of activities during 1971.

C.S.S. "PARIZEAU"

Master - A.G. Chamberlain   Chief Engineer - D. Marr

length overall	- 64.3 m (211' 9")	Displacement tonnage	1929.2 tons metric (1898.8 L.T.)
beam	- 12 m (40' 0")	total complement	- 51
draft	- 4.8 m (16' 0")	capabilities	- tidal & current survey, oceanographic.
shaft hp	- 3400	construction	- 1967, Burrard Dry Dock Co., Vancouver, B.C.
speed	- 15 kts		
range	- 12,000 n.m. (22,239 km)		

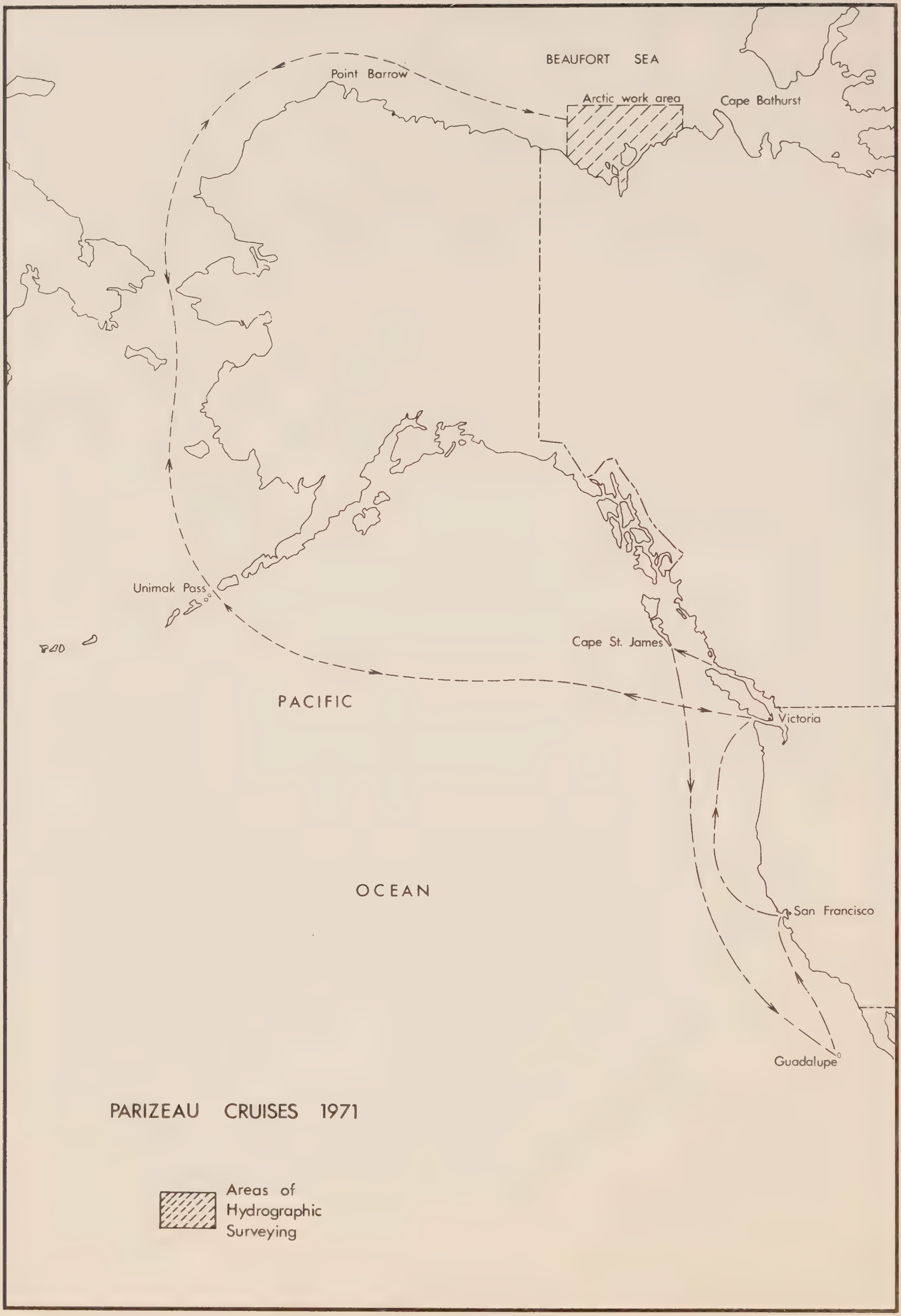
Prior to departure to the Western Arctic "Parizeau" served the requirements of P.O.G., M.S.B. (current metering) and M.S.B. (geophysics) and U.B.C. (geology)until June at which time the vessel's configuration was changed from oceanographic to hydrographic. During July-October, "Parizeau" was engaged in Western Arctic hydrography. Shearing of bilge keels and one major shell indent marked the total ice-damage sustained. Following a return to oceanographic configuration the ship completed the year in the service of M.S.B., P.O.G., U.B.C. and U. Vic.

C.S.S. "WM. J. STEWART"

Master - T.P. Scanlan   Chief Engineer - J.D. Henderson

length overall	- 65 m (214')	Displacement tonnage	- 1720.2 tons metric 1693.1 L.T.)
beam	- 10 m (34')	total complement	- 72
draft	- 3.9 m (13')	capabilities	- hydrography
shaft hp	- 1400	construction	- 1932, Collingwood Shipbuilders, Collingwood, Ont.
speed	- 11 kts.		
range	- 4000 n.m. (7,412 km)		

Following annual refit "Wm. J. Stewart" engaged in the annual hydrographer training exercise held this year in Saanich Inlet and adjacent areas during the period February 1 - April 16. From April 17 to October 15 she assumed her normal role in hydrographic surveys of Quatsino Narrows, Strait of Georgia and in the northern area around Dundas and Zayas Islands.



BEAUFORT SEA
Point Barrow
Arctic work area
Cape Bathurst
Unimak Pass
Cape St. James
PACIFIC
Victoria
OCEAN
San Francisco
Guadalupe
PARIZEAU CRUISES 1971
Areas of
Hydrographic
Surveying

C.S.S. "VECTOR"

Master - C.A. Macaulay   Chief Engineer - G.W. Clouston

length overall	- 39.6 m (130')	displacement tonnage	- 505 tons metric (500.5 L.T.)
beam	- 9.4 m (31')		
draft	- 3.3 m (11')	total complement	- 27
shaft horsepower	- 700	capabilities	- oceanographic (physical, chemical geology, biological)
speed	- 11 kts		
range	- 3500 n.m.	construction	- 1967, Yarrows Victoria, B.C.

Following the annual refit "Vector" served the requirements of MSB, IOUBC and POG mainly in Georgia Strait and the southern inlets. The only incident to marr an uneventful year was a grounding which fortunately caused only bottom paint damage, at the head of Rupert Inlet.

C.S.S. "RICHARDSON"

Master - V.L.E. Dale-Johnson   Chief Engineer - J.N. Henderson

length overall	- 19.8 m (65')	displacement tonnage	- 76.2 tons metric (75 L.T.)
beam	- 4.5 m (15')		
draft	- 2.1 m (7')	total complement	- 7
shaft horsepower	- 360	capabilities	- revisory survey, very limited oceanography
speed	- 10 kts		
range	- 2500 n.m.	construction	- 1962, Star Shipyards, New Westminster, B.C.

The requirement of a comprehensive four-year SCI survey and the decision to reassign this small ship to B.C. Coastal revisory survey led to the July 31 - August 25 passage from Tuktoyaktuk, N.W.T., to Victoria, B.C. This voyage was completely ice-free.

C.N.A.V. "LAYMORE"

Master - M. Dyer   Chief Engineer - T. Taylor

length overall	- 53.6 m (176')	displacement tonnage	- 645 tons metric (635 L.T.)
beam	- 9.7 m (32')		
draft	- 3.3 m (11')	total complement	- 33
shaft horsepower	- 1000	capabilities	- oceanography (physical, chemical, geology, biological)
speed	- 10 kts		
range	- 2500 n.m.	construction	- 1945, Kewaunee Ship Builders, Kewaunee, Wisconsin, U.S.A.

C.N.A.V. "Laymore" was made available during the 1971/72 fiscal year to the West Coast Working Group through MSB's 75% contribution of all operational costs including a comprehensive refit. During the period January 1 to November 1 this vessel served the scientific users of MSB, DREP, U.Vic., FRB, PEI, and Canadian Forces in coastal waters and offshore.

M.V. "PILOT II"

Master - R.J. Russel Chief Engineer - M. McGuire

length overall	- 21 m (70')	displacement tonnage	- 64 tons metric (63 L.T.)
beam	- 4.5 m (15')	total complement	- 8
draft	- .9 m (3')	capabilities	- limited hydrography
shaft horsepower	- 360	construction	- 1947
speed	- 11 kts		
range	- 1500 n.m.		

Pacific Region commenced hydrographic survey of the McKenzie River system from Hay River, to McKenzie Delta. In support of this assignment M.V. "Pilot II" was chartered during the period June 1 - September 15.

In addition to our activities on MSB vessels, a substantial use was made by MSB staff of the weatherships CCGS "Vancouver" and CCGS "Quadra" and of the CFAV "Endeavour", for deep sea oceanography.

LAUNCHES

With the exception of C.S.L. "Revisor", Pacific Region's twenty hydrographic launches and assorted powered craft performed exceptionally well and an operational efficiency of 98% was recorded. "Revisor" experienced an exceptionally poor performance year and suffered a multitude of mechanical breakdowns. The installation of new propulsion machinery is in progress.

DEPOT

The launch workshop facilities at the Victoria M.S.B. Depot were improved in 1971 and the efforts of the newly acquired shipwright and mechanical staff have contributed largely to the improvement in launch performance and reliability.

TASK FORCES, COMMITTEES AND SIMILAR ACTIVITIES

Stewart, R.W.

Joint Organizing Committee (JOC) of Global Atmoshperic Research Program (GARP) - Vice Chairman.

Canadian Committee for GARP.

Advisory Committee on Oceanic Meteorological Research (ACOMR).

Physical Oceanographic Commission of IAPSO - Chairman.

Scientific Committee on Oceanic Research (SCOR) - Canadian representative.

National Research Council - Advisory Committee on Physics.

IAMAP-IAPSO-SCOR Working Group on Air-Sea Interaction.

Marine Parks - Strait of Georgia Field Task Force.

Pacific Region Directors' Committee.

The Sea Use Council (USA) - Vice Chairman.

International Council of Scientific Unions - COSPAR Committee on Space Research.

The Royal Society of Canada - Selection Committee (interdisciplinary).

Departmental Requirements for Research Facilities - Task Force.

Federal-Provincial Task Force on Strait of Georgia.

Task Force on the Need for a West Coast Institute - Chairman.

Water Management Executive Committee.

English, W.N.

Working Group on Abatement of Pollution from D.O.E. Ships - Chairman.

Oil Spill Task Force Liaison Committee.

Departmental Committee on Conservation of Species and Areas of Natural, Cultural and Historic Interest.

West Coast Working Group (Canadian Committee on Oceanography).

Regional Group - Environmental Problems of the Lower Fraser River and Strait of Georgia.

Marine Parks - Strait of Georgia Field Task Force.

Intergovernmental Oceanographic Commission - Member of Canadian Delegation to Seventh Session.

Science Council Committee on Environmental Problems - Advisor (Essay on State of the Environment in British Columbia).

Comité d'Evaluation - Programme de Maîtrise en Sciences de l'Eau, Université du Québec.

Hydrographic Division

Ages, A.B.
Federal Task Force to Combat Oil Pollution.

Bolton, M.
West Coast Working Group, C.C.O. - Alternate.

Task Force on the Need for a West Coast Institute - Secretary.

National Hydrographic Survey Officers' Appraisal Board.

Sandilands, R.W.
Departmental Working Group on River Estuaries.

Workshop on Offshore Surveys for Mineral Resource Development.

Wigen, S.O.
Hydrographic Committee, Canadian Institute of Surveying.

Wills, R.
Survey Technology Advisory Committee, B.C.I.T.

Ocean Chemistry Division

Wong, C.S.
Advisory Committee - GEOSECS, Carbonate Chemistry Panel.

Advisory Committee - GEOSECS, Panel on standardization of the carbon dioxide system.

Advisory Committee on expanding GEOSECS.

Ocean Physics Division

Bell, W.H.
Federal Task Force on Moran Dam Project.

Garrett, J.F.
Canadian Delegation to Second Meeting of Intergovernmental Working Group on Marine Pollution.

Weathership Oceanography Committee.

Nasmyth, P.W.
IGOSS Group of Experts on Technical Systems Design and Development and Service Requirements - Chairman.

Tabata, S.
Intergovernmental Committee on Babine Lake Environmental Problems.

Federal Task Force on Moran Dam Project.

Federal-Provincial Task Force on Squamish Development Project.

Weathership Oceanography Committee.

Thomson, R.E.
Weathership Oceanography Committee.

RESEARCH AND DEVELOPMENT CONTRACTS

1.	Establish Carbon 14 dating laboratory for analysis of oceanographic and other samples - B.C. Research	$37,700
2.	Carry out study of remote sensing applications to hydrography and oceanography - Dr. J.F.R. Gower	$30,000 (2 years)
3.	Inform and demonstrate to Canadian scientists the Japanese approach to problems in Arctic oceanography - Dr. K. Fujino, Hokkaido University	$26,000 (2 years)
4.	Develop selfcontained tide gauge for Arctic use - Institute of Oceanography, University of British Columbia	$12,000
5.	Study temperature and conductivity microstructure in inlets and seas as an aid to understanding turbulent mixing and transport - Institute of Oceanography, University of British Columbia	$20,000 (18 months)
6.	Study interaction of tide, wind and fresh water run-off and their effects on mixing and transport - Institute of Oceanography, University of British Columbia	$16,000 (18 months)
7.	Interpret colour aerial photography of Strait of Georgia to assess feasibility of determining depth contours and high and low water-lines - Airphoto Analysis Associates	$8,000

PATENTS AND LICENSING AGREEMENTS

There were no patents issued or applied for in 1971.

Licensing agreement:

Manufacture of Frozen Sea Arctic Research Units comprising sled, winch, heated enclosure, generator temperature control and waste heat utilization system and engine starting techniques and ice drilling system:

made with (Ocean Components Ltd.
(International Hydrodynamics Ltd.
(National Electrolab Associates Ltd.

PUBLICATIONS

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Garrett, J. F. and R. W. Stewart. 1971. Review of Düing, W. The monsoon regime of the currents in the Indian Ocean. *WMO Bull*, 20:209.

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PROFESSIONAL AND TECHNICAL STAFF

DIRECTOR
R.W. Stewart; B.Sc., M.Sc. (Queen's), Ph.D. (Cantab.), FRSC, FRS.

DEPUTY DIRECTOR
W.N. English; B.A. (Brit. Col.), Ph.D. (Calif.)

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R.M. Cotton
M.I.K. Craton
R.W. Crouch
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J.E. Parsons
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P.O. Lee; Dip. B.C.I.T.
B.M. Lusk
A.G. Lyon
C.G. McIntosh; Master Mariner, F.G.
A.R. Mortimer; Master Mariner, F.G.
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R.A. Pierce
T.C. Plume
R.D. Popejoy
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G.E. Richardson
G.W. Rogers
C.F. Ryan; Dip. R.R.E. (England)
R.W. Sandilands; Lt. R.N. (ret'd)
F.R. Smithers
T.J. Soutar; Dip. B.C.I.T.
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M.S. Taylor
W.R. Taylor; Dip. R.C.C.
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V.N. Young

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P. Vandergugten; Dip. B.C.I.T.

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P.W. Nasmyth; B.A.Sc., M.A., Ph.D. (Brit. Col.); Head of Division
K. Abbott-Smith
W.H. Bell; B.A.Sc. (Brit. Col.), M.Sc. (Hawaii)
R.H. Bigham
G.W. Chase; Dip. B.C.I.T.
P.B. Crean; B.Sc. (Dublin), M.A.Sc. (Tor.)
C. de Jong
A.J. Dodimead; B.A., M.A. (Brit. Col.)
R.E. Forbes
K.A. Gantzer
A.E. Gargett; B.Sc. (Man.), Ph.D. (Brit. Col.)
J.F. Garrett; B.A. (Harvard), Ph.D. (Brit. Col.)
L.F. Giovando; B.A., M.A., Ph.D. (Brit. Col.)
H.W. Hansen; Dip. B.C.I.T.
D.A. Healey; B.Sc., M.Sc. (Brit. Col.)
R.H. Herlinveaux
H.J. Hollister
R.A. Lake; B.Sc. (Brit. Col.), M.Sc. (Washington)
E.L. Lewis; B.Sc., M.Sc., Ph.D. (London)
J.H. Meikle
B.G. Minkley; Dip. B.C.I.T.
R.G. Perkin; B.A.Sc., M.S. (Brit. Col.)

D.B. Smith; B.Sc. (Victoria)
J.A. Stickland
R.B. Sudar; B.A.Sc. (Tor.)
S. Tabata; B.A., M.A. (Brit. Col.), D.Sc. (Tokyo)
R.C. Teichrob, Dip. B.C.I.T.
R.E. Thomson; B.Sc., Ph.D. (Brit. Col.)
E.R. Walker; B.Sc. (Man.), M.A. (Tor.), Ph.D. (McGill).

SENIOR RESEARCH ASSOCIATE
W.M. Cameron; B.A., M.A. (Brit. Col.), Ph.D. (Scripps)

SHIP DIVISION
E.N. Geldart; Dip. I.M.E. (London); Marine Superintendent
F.S. Green; Master Mariner ; Assistant Marine Superintendent
K.J. Sjoholm; Master F.G.; Relief Master
C. Barboza; First Mate F.G.; Relief Mate
B. Aaron; Engineer First Class Combined, Relief Chief Engineer
R.P. Houle; Engineer 4th Class; Relief Engineer

C.S.S. Parizeau
A.J. Chamberlain; Master (F.G.); Master
H.J. Andrews; Naval Certificate; 3rd Officer
J.N. Christie; Radio Certificate, W/O
L.E. Clarke; Supply Officer
D. Marr; Engineer First Class Combined; Chief Engineer
W.G. Delany; Engineer 2nd Class Motor; Senior Engineer
P. Napier; Engineer 2nd Class Motor; First Engineer
J.W. Munroe; Engineer 3rd Class Motor; 2nd Engineer
G. Kyle; Engineer 4th Class Motor; Third Engineer

C.S.S. Wm. J. Stewart
J.P. Scanlan; Master F.G.; Master
J.G. Marston; Master F.G.; First Officer
J.W. Grocutt; Master H.T., Second Officer
C.M. McIntyre; Master 350 T; Third Officer
S. Palmer; Supply Officer
J.D. Henderson; Engineer 2nd Class Steam; Chief Engineer
R.B. Gibson; Engineer 3rd Class Steam; Senior Engineer
R.E.Mugford; Engineer 2nd Class Steam; First Engineer
G. Loopeker; Engineer 4th Class Steam; Second Engineer
A. Conway; Engineer 4th Class combined; Third Engineer

C.S.S. Vector
C.E. Macaulay; Master H.T.; Master
J.G. Alcorn; Master H.T.; First Officer
R.J. Easson; Master F.G.; Second Officer
G.W. Clouston; Engineer Third Class Motor; Chief Engineer
T.H. Storer; Engineer Third Class Motor; First Engineer
R. Pearson; Engineer Fourth Class Motor; Second Engineer

C.S.S. Richardson
    J.N. Henderson; Engineer Fourth Class Motor; Chief Engineer

C.F.A.V. Laymore
    M. Dyer; Master
    T. Taylor; Chief Engineer

M.V. Pilot II
    R.J. Russel; Master
    M. McGuire; Chief Engineer

Depot Supervisor
    V.L.E. Dale-Johnson; Master 350 T.

MARINE SCIENCES DIRECTORATE
PACIFIC REGION

ANNUAL REPORT, 1972

ENVIRONMENT / CANADA
Fisheries and Marine Service
Marine Sciences Directorate
Pacific Region
1230 Government St.
Victoria, B.C.

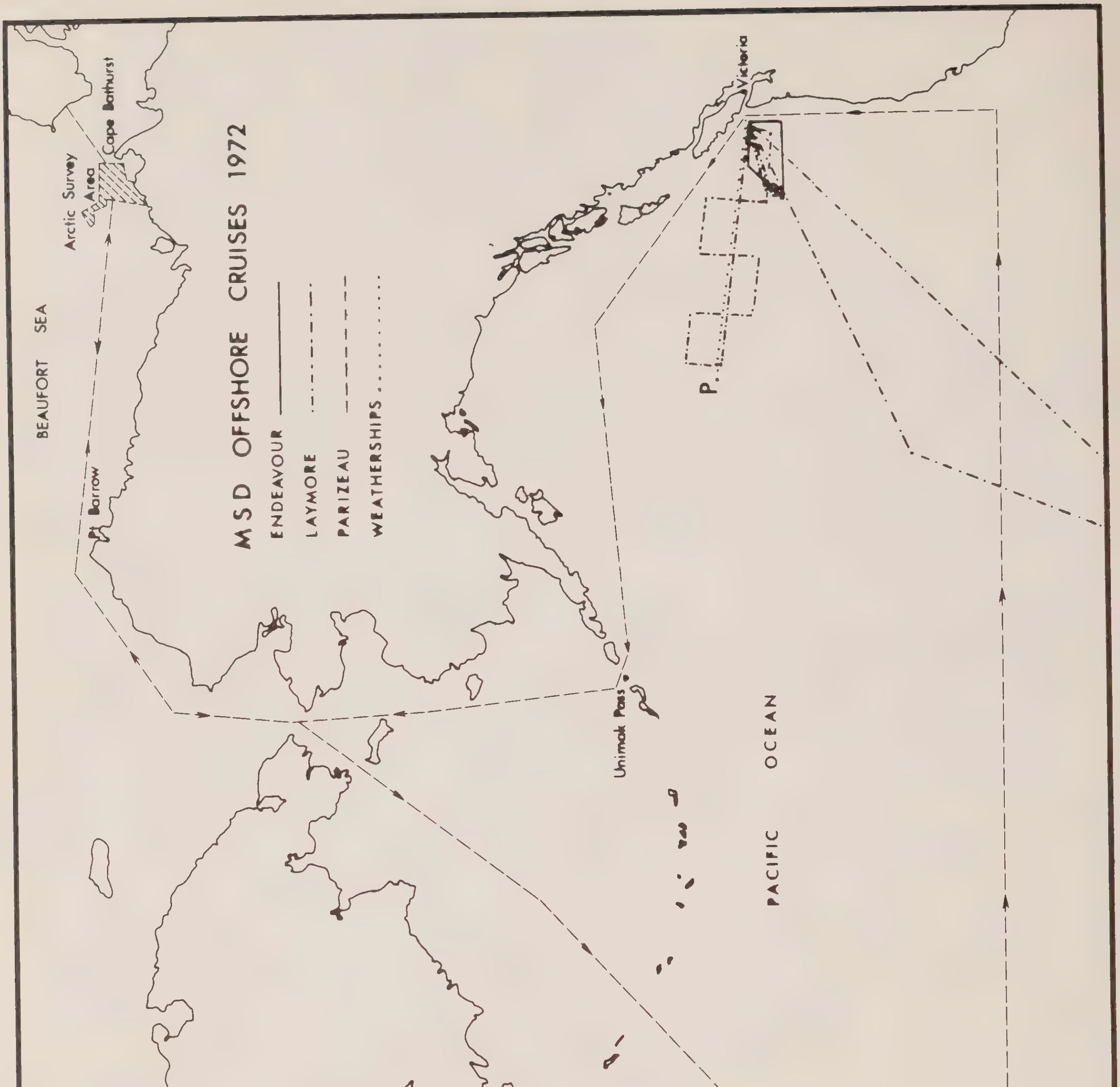
MARINE SCIENCES DIRECTORATE

PACIFIC REGION

ANNUAL REPORT 1972

Telegraph Harbour in the Strait of Georgia's Gulf Islands is one of the hundreds of small anchorages on the British Columbia coast which are feeling the pressure of the pleasure boating boom.

Victoria, March 1973.


MSD OFFSHORE CRUISES 1972
ENDEAVOUR
LAYMORE
PARIZEAU
WEATHERSHIPS
BEAUFORT SEA
Arctic Survey Area
Cape Bathurst
Pt Barrow
Victoria
P.
Unimak Pass
PACIFIC OCEAN
Tokyo

For the Marine Sciences Directorate, Pacific Region, 1972 was a year which may in retrospect appear as a calm between storms. The intensive reorganization which occurred in 1971 had comparatively mild sequels in 1972, and although the future promises much more extensive reorganization and relocation of the work and personnel of the Region, these impending changes had little effect on the work carried out during the year. As is to be expected in the Department of the Environment, there were many ad hoc tasks demanded of us, but these did not prevent substantial progress being made in ongoing programs.

In 1972 the Hydrographic Division made good progress in the continuing survey program for the B.C. coast. The main portion of the Strait of Georgia has now been completed, as has a new survey of Massett Harbour and approaches in the northern area.

Hydrographic and geophysical surveys in the Beaufort sea were conducted from CSS PARIZEAU, which again spent the summer in the Arctic. Further data were collected for the delineation of the underwater pingo-like features of this area.

A new charter vessel, the RADIUM EXPRESS, was employed on the Athabasca-Mackenzie waterway. The use of this vessel greatly enhanced our continuing surveys along this important transportation artery which grows in importance with the rapidly expanding activities of the petroleum industry in the Arctic.

Closer to home, a large scale survey was completed of Secret Cove and Smuggler Cove on the Sechelt Peninsula, the results of which will be of value to the many fishermen and recreational boaters now using this area. Also as an aid to the boater a manuscript for the first edition of the B.C. Small Craft Guide, Vol. 1, has now been completed.

Research and development on new hydrographic techniques has continued. The introduction of side scan sonar and the velocity meter into this program is expected to have an important impact on future hydrographic work as will the continued studies into the development of airborne hydrographic techniques.

A notable event in 1972 was the visit of PARIZEAU to Japan in October. PARIZEAU went directly to Japan from the Arctic and in Tokyo became the centrepiece of the Canadian display at the 2nd International Ocean Development Conference and Exhibition. This Canadian display, organized by the Department of Industry, Trade and Commerce, was exceedingly well received -- to the extent that a Japanese newspaper headlined "Canada flexes muscles".

On the return from Japan, PARIZEAU carried out TRANSPAC 72, a chemical oceanographic expedition along 35^{o}N across the whole Pacific. The marine CO_2 cycle, circulation in the North Pacific and oil aggregates in the surface waters were studied.

The Ocean Chemistry Division has now completed its move from Nanaimo to new laboratories at our Marine Depot in Victoria. It is to be expected that the Chemistry Division can now "settle in", and at least for some time in the future avoid the effects of frequent moves which have disrupted its work over the past few years. The radio carbon dating laboratory which is being established under our supervision and auspices on the premises of B.C. Research in Vancouver was at the end of the year on the point of becoming operative. The division has been substantially strengthened in personnel and new programs have been initiated in marine hydrocarbons and trace metals, in particular lead and mercury, in the marine environment.

The efforts of the Ocean Physics Division continued to be hampered by the fact that its personnel are scattered over six different locations in Victoria, Esquimalt, West Vancouver and Vancouver. However, substantial progress has been achieved in a wide variety of programs. A concerted effort has been made in Babine Lake in support of Fisheries Service work aimed at attempting to establish the carrying capacity of this lake for salmon following the construction of extensive artificial spawning channels. This work lies outside our terms of reference, but has been undertaken because of its urgency and the fact that the Inland Waters Directorate was unable to carry it out at the requisite time. Our participation in field work in this lake will not extend beyond 1973.

The interests and activities of this Division in the use of airborne and satellite techniques continues to grow. A cooperative program with the French Centre National de la Recherche Scientifique, in which we deployed a number of French buoys in the central North Pacific where they were tracked by the EOLE satellite, yielded very valuable experience. We are also taking a very active role in making use of imagery from the earth resources technology satellite (ERTS 1) and from remote sensing aircraft for oceanographic purposes.

An increasing amount of effort of the Region is being applied towards the numerical modelling of physical phenomena in water bodies of major concern. We now have working one-dimensional numerical models of Victoria Harbour, the lower Fraser River, and Babine Lake, and a working two-dimensional model of the Juan de Fuca-Georgia Strait area. Progress is being made towards three-dimensional modelling.

Ongoing programs as widely scattered as those at Ocean Weather Station "P" in the North Pacific and in Greely Fjord and Cambridge Bay in the Arctic, and Howe Sound on the City of Vancouver's doorstep, continue to demand our attention. In addition, however, MSD, Pacific played an active part in the Department's response to the two significant oil spills which occurred on this coast during 1972. We have also played a substantial role in such environmental impact studies as those on the Squamish Estuary, the Vancouver "Third Crossing" and the Moran Dam. It is to be anticipated that even more of our efforts will have to be directed to such work in the future. It is our responsibility to ensure that our ongoing programs keep us in a position to respond effectively and quickly in such situations.

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

The activities of the Hydrographic Division are summarized in the following sections. There are sixty-five full time continuing employees in the Division, over half of whom are considered to be field personnel. Demands on Hydrography continued to grow, far outreaching the resources available.

Detailed planning for a Pacific Coast interdisciplinary resource charting survey was commenced, with Hydrography assuming the role of lead agency. Plans for a major tidal current survey at the northern and western boundaries of the Strait of Georgia are well developed. Both of these major surveys will be undertaken in 1973. Arrangements for the 1973 Canadian Hydrographic Conference, to be hosted by Pacific Region in February, have been completed.

The Region again participated in the Hydrography I (Basic) training program, with the field training being conducted from CSS WILLIAM J. STEWART. One senior field hydrographer audited the Hydrography II training course given at CCIW. Several staff members attended various courses at the University of Victoria, and one hydrographer attended full time in the University Training Plan.

Administration of the Library was transferred to the Division during the year.

M.V. Revisor at anchor near Discovery Island. Ships' staff have just assembled the sweep apparatus and one of our divers is checking the depth of the wire drag.

FIELD HYDROGRAPHY

R. Wills, Regional Field Superintendent
E. B. Clarke
F. A. Coldham
I. J. Campbell
G. H. Eaton
N. S. Fujino
K. Highten
R. C. Hlina
J. B. Larkin
B. M. Lusk
C. G. McIntosh
A. R. Mortimer
R. D. Popejoy
A. R. Raymond
G. E. Richardson
G. W. Rogers
R. W. Sandilands
C. R. Tamasi
M. V. Woods
P. Y. Yee

Hydrographic surveys were carried out in the Pacific Region in 1972 on the same scale as in recent years and the projects undertaken were mainly a continuation of long range programs. A withdrawal of funds about mid season made necessary a reduction in overtime worked and a slightly earlier than normal end of field season, with a consequent failure to fully complete all projects as originally planned.

The Wm. J. STEWART (C.G. McIntosh) sailed from Victoria on May 4. Her survey areas included the northern Strait of Georgia, Masset Harbour and approaches and the approaches to the Skeena River. A Mini-fix chain in the hyperbolic mode was used for positioning in the Strait of Georgia and in other areas RPS, hydrodist and sextant were employed. Modern survey coverage of the whole of the main portion of the Strait of Georgia has now been completed and it is expected that remaining inshore sections including Malaspina Strait, Powell River and Westview will be completed in 1973. Masset Harbour and approaches, last surveyed in 1907, has been completed to modern standards and also the portion of the Skeena River approaches as required to complete coverage for new Chart No. 3985. Primary adjusted control has been established for further surveys of the Skeena River and Arthur and Telegraph Passages. Small revision surveys were carried out in Sechelt Rapids and Prince Rupert Harbour.

The PARIZEAU (R.W. Sandilands) carried out hydrographic surveys, including the collection of magnetic and geological data, in the eastern Beaufort Sea from 27 July to 30 August, having sailed from Esquimalt 4 July and run Gebco sounding lines en route. These surveys at 1:100,000, were a continuation of previous work in the area. An area of 2325 square nautical miles was sounded, 2600 n.m. magnetic profile surveyed, 121 shoals were examined and 133 bottom samples were obtained. At the request of Northern Transportation Company Ltd., Sachs Harbour was resurveyed at a scale of 1:10,000 and a reconnaissance survey of Harrowby Bay was made at a scale of 1:100,000. The Decca Lambda chain established by PCSP was used for positioning in the Beaufort Sea, and the assistance and co-operation given by the Project staff in helicopter transportation services and accommodation for personnel in transit at Tuktoyaktuk is gratefully acknowledged.

Setting a bench mark, and burying capillary tubing for pressure tide gauge at Liverpool Bay, N.W.T.

From 1 to 11 September a party of four from Geological Survey under Mr. J. Shearer were on board PARIZEAU and a total of 1,010 nautical miles of seismic profile were run in the area between Mackenzie and Franklin Bays. In addition 11 cores were obtained, five on or close to pingo-like features and six on a line to give a sampling of the shelf.

On conclusion of Arctic surveys the PARIZEAU proceeded directly to Japan to participate in the Second International Ocean Development Conference and Exhibition, Tokyo. Gebco sounding lines were continued en route and throughout "Transpac-72". When not engaged on Arctic surveys, hydrographic personnel from the PARIZEAU partly carried out a survey of Esquimalt Harbour which is now 95% complete.

The REVISOR (B.M. Lusk) continued her revisory survey program in southern areas including annual revisions to Vancouver Harbour and the Fraser River. In addition numerous investigations were carried out as the result of reports of new dangers, chart changes, etc. received from the Ministry of Transport, Canadian Power Squadrons, and other sources. The conventional survey of Juan de Fuca and Haro Straits, begun in 1971 was continued and the sourthern field sheet of Juan de Fuca Strait was completed as well as 50% of the northern sheet (Haro Strait).

This year the continuing program on the Athabasca-Mackenzie Waterway was carried out by the charter vessel RADIUM EXPRESS (G.E. Richardson). The vessel and other resources available proved to be a considerable improvement over the facilities of previous years. Sounding was completed from

Camsell Bend to Wrigley, also most of the area from Fort Good Hope to Travaillent River. Reconnaissance surveys were again conducted in the delta, mainly Middle Channel with its many branches leading north from Tununuk to Mackenzie Bay. Napoiak, Taylor and Schooner Channels were also investigated. Many small sounding surveys including Burnt Island, Birch Island, Ft. Norman as well as new ranges, were carried out in conjunction with the normal revisory surveys from Mile 0 to Tununuk. Temporary water level gauges were again operated, gauging stations being established at Miles 738 and 802 and in the Ramparts area. These records are being used in the establishment of a reasonable low water datum for surveyed portions of the river.

An independent launch party (A.D. O'Connor) conducted a large scale survey of Secret Cove and Smuggler Cove on the Sechelt Peninsula, the results of which will be of value to the many thousands of fishermen and recreational boaters now using the area.

Eroding cliffs at Nicholson Peninsula gauging station. Liverpool Bay, N.W.T. Rapid erosion is a common feature of the Western Arctic coast.

HYDROGRAPHIC DEVELOPMENT GROUP

N.M. Anderson, Head
A.D. O'Connor*
J.A. Vosburgh*
P.O. Lee*
R.A. Pierce*
*Rotational Hydrographic Staff

Side Scan Sonar Evaluation. This program has included improvements in towing, depression, and stability; range, resolution and signature repeatability tests; and the development of an expertise in tuning and interpretation. The operational technique can be used to realize the full potential of the side scan concept as a valued aid to hydrography. A detailed report covering all aspects of the concept has been prepared and will be presented at the Annual Hydrographic Conference.

Velocity measurements were taken using a velocimeter (N.U. Sonic Corp. Model 1000-005) and velocity corrections were applied to simultaneous soundings taken by echo sounders in current use. The results have been tabulated and recommendations concerning echo sounder acquisition and operation have been made in a report to be given at the Annual Hydrographic Conference.

Air photography. The University of New Brunswick under contract with the Marine Sciences Directorate Pacific is continuing a program to develop the techniques of stereoscopically measuring water depth from aerial photographs using the analytical plotter.

Fundamental to the development of airborne hydrographic techniques is the determination of position and attitude of each photograph. Traditionally this is done by aerotriangulation of photo identifiable, ground control points which are often not available in marine applications. An opportunity was presented by the Canada Centre for Remote Sensing (CCRS) to develop a system using the Lytton Inertial Navigation System (LTN-51) for the determination of attitude and position. An engineer and a technician from the Marine Sciences Directorate Pacific will be assigned to the project for its duration (approximately 18 months).

Underwater audio communications are needed to increase diver efficiency and provide diver-surface coordination during complex operations. Two systems, HELLEPHONE and SUBCOM, were evaluated and purchase of the SUBCOM system recommended. A report on this system will be included in the Pacific Region's Annual Diving Report which will be presented at the Annual Hydrographic Conference.

Wallace and Tiernan altimeters (Model FA 181) were tested for height determination and repeatability. Tests on two instruments were carried out to determine the feasibility of using them for measuring the heights of structures or geographic features presently measured by other means. A report has been prepared.

SAILING DIRECTIONS SECTION

T. Jones, Head
J.W. Chivas

The projects undertaken by this section in 1972 were:

(a) The completion of the compilation, in a new format, of the 8th Edition of the B.C. Sailing Directions (Pilot), Vol. I.

(b) The completion of the manuscript for the 1st Edition of the B.C. Small Craft Guide, Vol. I.

(c) A start to the compilation, in a new format, of the 6th Edition of the B.C. Sailing Directions (Pilot), Vol. II.

During April visits were made to the marinas and other small craft facilities on Vancouver Island, between Sooke and Nanaimo, for the purpose of collecting information and photographs for the Small Craft Guide, Vol. I.

In May, advantage was taken of the last sailings of the Northland Navigation Company's SKEENA PRINCE to circumnavigate Vancouver Island for the purpose of taking photographs and obtaining new information for both volumes I and II of the B.C. Sailing Directions.

In July, the section had the use of CSL FALCON and a coxswain to cruise through the Gulf Islands to collect photographs and small craft information for inclusion in the Small Craft Guide.

The revision of B.C. Sailing Directions, Vol. II, like that done for Vol. I is a major undertaking as it involves a fairly drastic pruning of redundant material in accordance with the policy for the new format, as well as the addition of some new information for the use of small craft. Five of the eleven chapters have been revised.

The oil slick from the freighter VANLENE, ashore in Barkley Sound, Vancouver Island.

TIDAL AND CURRENT SECTION

S.O. Wigen - Regional Tidal Superintendent

The Tidal and Current Section conducts field programs in the Pacific and Western Arctic Regions, and in the Mackenzie-Athabasca Waterway. Its activities for 1972 are reported under the four Units of the Section.

Hydraulic Research

A.B. Ages	K.S. Lee
A.N. Douglas	A.L. Woollard

The one-dimensional numerical model of the Fraser estuary was extended to include the upper tidal reaches of the river and Pitt Lake. The effect of critical freshet discharges upon the delta and its response to a proposed diversion canal were examined by the model. Salinity measurements in the delta were continued. An earlier developed model of Victoria Harbour was further refined and tested.

The Unit participated in the measurement and assessment of two oil spills in the Pacific Region, from the VANLENE grounding in Barkley Sound in March, and from the Atlantic Richfield refinery mishap at Cherry Point, Washington, in June.

The freighter VANLENE, bound for Vancouver from Japan, ran aground on the evening of March 14 at the entrance to Barkley Sound on the west coast of Vancouver Island. Although the weather conditions hindered the oil retrieval operations the heavy precipitation proved to be a blessing in disguise; fresh water runoff tended to keep the oil away from the shores. However, some areas did receive a quantity of oil on the beaches and these are being studied by biologists. A.B. Ages and R. Herlinveaux of the Coastal Zone Oceanography Section were actively engaged in the assessment of the effects of the spill.

Current Surveys

W.S. Huggett	F.V. Hermiston
J.F. Bath	W.J. Harris
T. McNie	S. Ames
K. Morgan	

A current survey was carried out in Vancouver Harbour in the period March to May, 1972. The area of survey extended from westward of First Narrows to eastward of Second Narrows.

At the same time, twenty-one current meters were placed in the Strait of Georgia. Ten were moored in positions around the entrance of Howe Sound and Burrard Inlet. One supplied near-bottom velocities for a feasibility study of a pipeline crossing under the Strait of Georgia, and the rest were reoccupations of former stations where longer series of records were required.

A current meter established in Baynes Channel in 1971 and scheduled to run for one year was terminated in March 1972 due to mooring difficulties. The meter moored off Race Rocks is still in position. At both stations sufficient data have been obtained for harmonic analysis and tidal current predictions.

A current meter installed off Robert Banks will be left in place for a period of one year, and in the meantime, is used to give current velocity readings to the Pilots bringing freighters into Westshore Terminals at Robert Banks.

All data from the current meters in the Strait of Georgia survey have been processed and data from lines 2, 4 and 5 have been published. Line 6 is ready for the printers, and line 3 should be ready early in 1973. A draft copy of Vancouver Harbour currents has been completed, and it is hoped to have the final copy out by the middle of next year.

Water level bubbler gauge in its portable gauge shelter at a site on the Mackenzie River.

Tidal Survey

W.J. Rapatz F. Stephenson
R.E. Brown

The Tidal Survey Unit continued its program of water level gauging on the Mackenzie River. Two bubbler gauges were operated in the region between Fort Good Hope and Arctic Red River. The records obtained from these gauges were supplied to hydrographic personnel charting the River. Low water datums were established at the two sites. From Fort Good Hope to the Delta the lack of long-term water level records makes it necessary for future gauge operations to be conducted before charting datums can be established.

In the Western Arctic, tidal studies were conducted along the coast of the Tuktoyaktuk Peninsula and on the perimeter of Liverpool Bay. Nine gauge stations were operated during July and August. Five of these in Liverpool Bay established a preliminary model of tidal patterns in an area where the complex coastline and shallow depths create significant tidal variations in a short distance. This work is an extension of the 1971 tidal study of Eskimo Lakes.

On the British Columbia coast, twelve gauge stations were operated in Juan de Fuca and Georgia Straits as part of the continuing tidal and current studies in these waters.

The teleannouncing tide gauge stations at Steveston and New Westminster have been kept in operation for the benefit of navigators in the Fraser River. The teleannouncing gauge at Tofino has been maintained as a link in the tsunami warning network. Severe storms last winter caused the loss of most of the underwater components of the Langara Island tsunami warning gauge. Since then the installation has been rebuilt using part of the old system but incorporating a much less vulnerable arrangement. The new complex is expected to be in operation by early 1973.

Data Processing

C.E. Stenning
L.E. Ponse
S. Gill
D.E. Hilder

The Data Processing Unit processed all Marine Sciences Directorate tidal records for the Pacific and Western Arctic regions, and forwarded the data to Ottawa for analysis and inclusion in "Water Levels Volume 3".

CHART CONSTRUCTION SECTION

F.R. Smithers, Head
R. Banyard
R.D. Bell
P.C. Browning
D.J. Clark
J.H. Coldwell
E.M. Coulter
D.G. Dobson
K.R. Holman
A.G. Lyon
I.M. Mani
C.J. Nast
M.M. Patton
T.C. Plume
M.S. Taylor
L.G. Thomson
B.M. Watt
V.N. Young

This Section is responsible for the compilation, revision, correction and distribution of the Pacific Region charts and publications. We are also required to provide illustration, drafting, photographic and printing services for the Region.

Compilation

The compilation unit has completed Chart 3687 "Plans in Quatsino Sound" and is processing eight compilations as listed below:

Chart	3512	Ballenas Is. to Cape Lazo
	3532	Baynes Sound and Approaches
	3901-L	Queen Charlotte Sound
	3980	Plans in Smith and Chatham Sounds
	3985	Approaches to Prince Rupert Harbour
	3989	Brown Passage
	3991	Hudson Bay Passage
	3992	Approaches to Portland Inlet

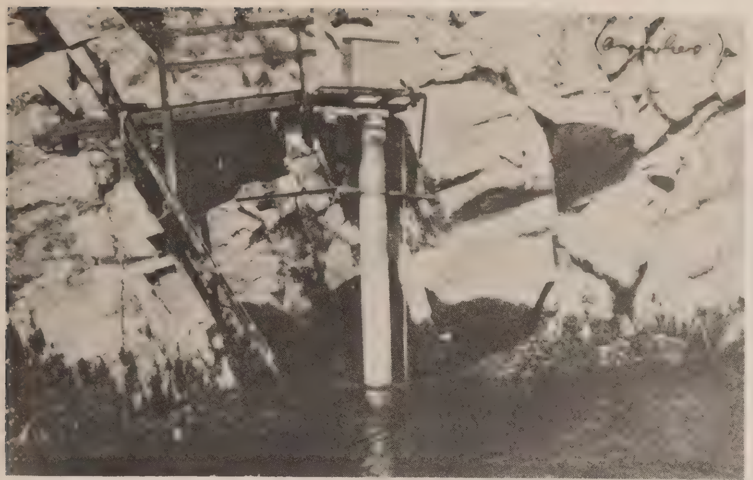
Since July 1972 we have built and set up displays aboard CSS PARIZEAU on her recent visit to the 2nd International Ocean Development Conference in Tokyo, Japan and built four modules for the 1973 Departmental Shopping Mall displays in addition to providing internal illustration and photographic services.

Strait of Georgia Model

Revision, correction and distribution

The revision unit compiled 12 new editions of nautical charts as a result of new survey data and major hydrographic changes. We processed 132 Marep reports from Power Boat Squadron for chart correction or revisory survey action. We promulgated 12 Notices to Shipping and 50 Notices to Mariners for publication by the Ministry of Transport. The chart correction staff have amended 144,227 charts which required 1,669,046 individual hand corrections before they could be distributed to our dealers for sale to the general public. Our chart distribution staff has processed and shipped 130,089 charts, 24,568 tide tables, 2,580 related nautical publications, 158 tidal current atlases and 1,323 miscellaneous prints. The premises of 38 chart dealers were inspected during the year.

Nautical chart displays were manned at the Vancouver International Boat and Sport Show, and, in conjunction with the Departmental exhibit, at two shopping centres in Vancouver and Victoria.



*Winchelsea Island, B.C.
Tide gauge stilling
well and transmitter.*

SURVEY ELECTRONIC SECTION

J.V. Watt, Head	C.F. Ryan
L.W. Dorosh*	W.R. Taylor
R. Mogden*	T.J. Soutar
J.L. Rainko**	J.S. Wallace

*joined during 1972
**left during 1972

The Survey Electronics Section provides electronics engineering and technical support as required by the survey, ships and research operations in the Pacific Region.

The requirements for electronics operational and maintenance support continued to increase with a significant portion of the additional duties being attributable to the 1972 major equipment acquisitions of a velocimeter, a side scan sonar system and another short-range positioning system (Motorola 'Mini-Ranger'). The addition of 'C-Band' test equipment and procedures for calibration and maintenance of the Mini-Ranger System (5.5 GHz) constitutes the major change in the area of operations and maintenance.

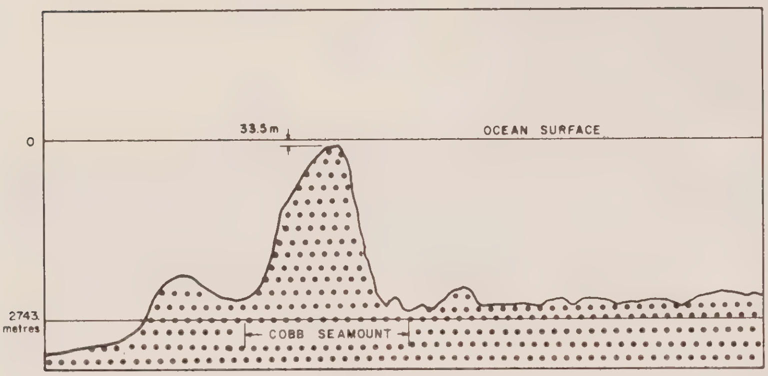
The Section provided full time field support to the WM.J. STEWART party and to the PARIZEAU during the Western Arctic operations and on the Transpac-72 cruise. Further support was provided on an 'as required' basis to the PARIZEAU Juan de Fuca Strait geophysical cruise, to the Mackenzie-Athabasca party, to the local operations of the REVISOR party, the Esquimalt Harbour party and the Secret Cove party, and to the ships VECTOR and RICHARDSON.

The design, development and construction talents of the section were exercised on projects such as trackable drifter buoys, assembly of the velocimeter equipment, examination of an Atlas sounder on loan from Central Region, design and construction of a X-Y recording BT system for applications in Babine Lake, continued work on a thermistor chain/data acquisition system for Babine Lake, and a study of the errors in radar transponder positioning systems related to transponder delay variations.

LIBRARY

D. Stastny, Librarian

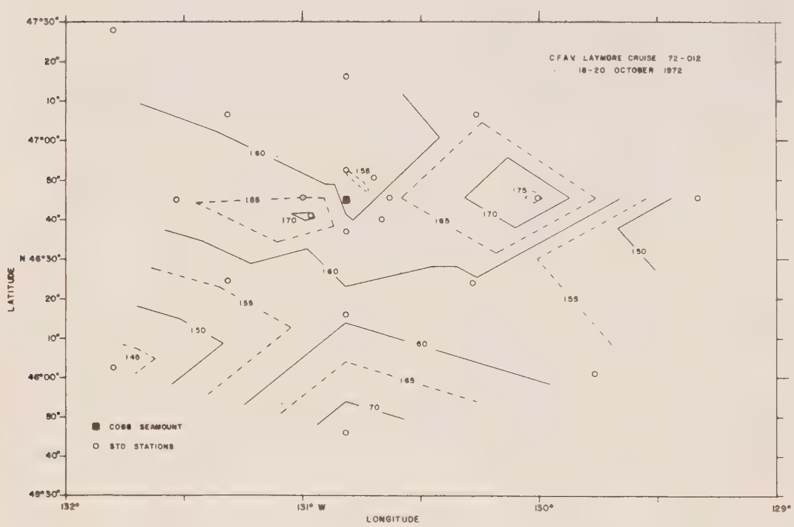
During 1972 the library was staffed by 1 clerical assistant and 1 professional librarian on a part-time basis. The collection increased to about 2850 volumes (2700 titles) including 132 reference titles, 125 journal subscriptions with 7 complete runs on microfilm, 50 microfiche and a collection of reprints; much of this material was added by gift or exchange.



EAST-WEST PROFILE OF COBB SEAMOUNT

Cobb Seamount, a submarine mountain 200 miles off the coast which rises to within 34 m of the sea surface, has a measurable effect on local oceanographic structure. In particular the potential energy surfaces, which are related to water density, are displaced upwards near the seamount.

POTENTIAL ENERGY at 100metres

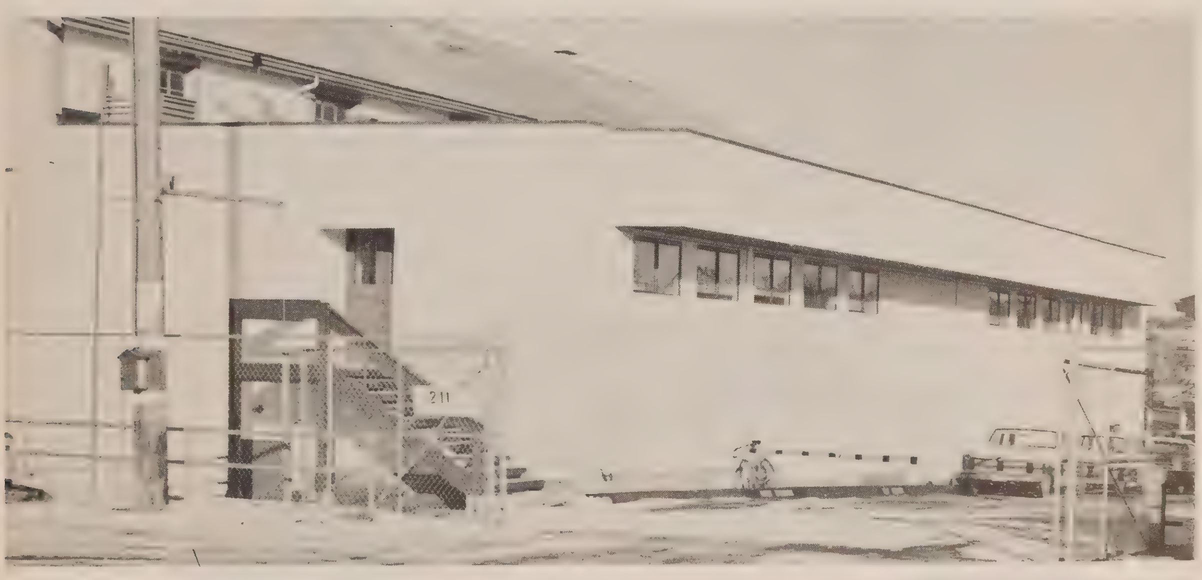


OCEAN ENGINEERING DIVISION

FACILITIES AND ENGINEERING PLANNING SECTION

N.A. Todd, Head

The West Coast Institute - The realization of the long talked-of Marine Sciences "West Coast Institute" is without doubt closer in absolute terms than it was at the end of 1971. The elasticity of the time-scale, accepted with historically induced stoicism, is however, accompanied each year by a more acute awareness that the effectiveness of the regional programs is suffering increasingly both from the spatial barriers existing among the various groups and from inadequate facilities. A review of those necessary administrative preliminaries which occurred during the year gives substance to the claim that the date of entry is closer now than it was this time last year.



New Ocean Chemistry Laboratories attached to the Depot Building at 211 Harbour Road, Victoria were completed in November, 1972 for accommodation of the Ocean Chemistry Division formerly located in Nanaimo.

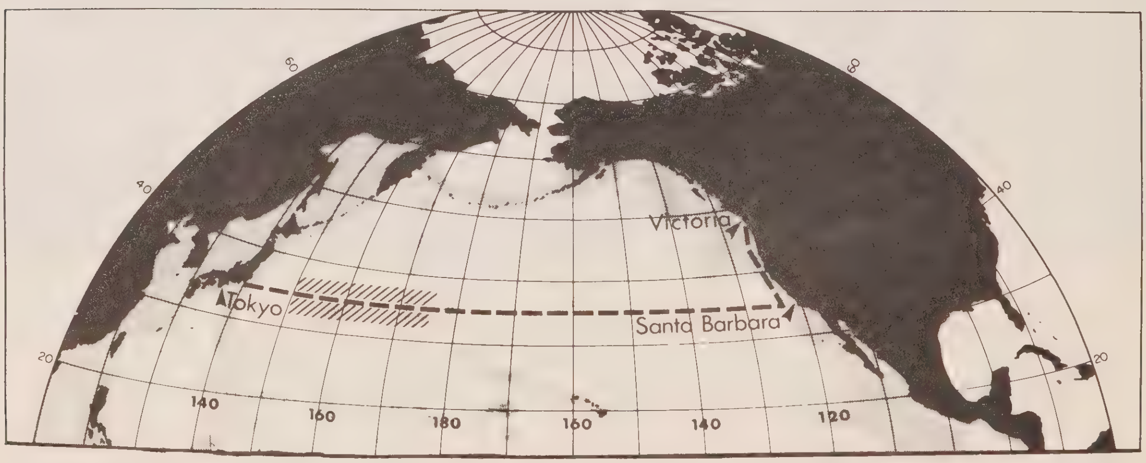
OCEAN CHEMISTRY DIVISION

C.S. Wong, Head
A.B. Cornford
W.J. Cretney
D.J. Francis (NRC Postdoctoral Fellow)
R.D. Bellegay
P. Vandergugten
C.M. Jackson

The main activities of Ocean Chemistry Division in 1972 included the establishment of new chemical laboratories in Victoria and a radiocarbon dating laboratory in B.C. Research (Vancouver), a TRANSPAC-72 expedition from Tokyo to Victoria, a continuing chemical monitoring program at Station "P" and initiation of new programs in marine hydrocarbons and trace metals. The Division was expanded from a strength of 3 in 1971 to 7 in 1972, with two additional graduate students from UBC and UVic working towards their Ph.D. degrees in our laboratories.

Establishment of new laboratories

The new laboratories at 211 Harbour Road, Victoria are designed for chemical oceanographic analyses, nutrients, trace metals, carbonate chemistry, atmospheric and oceanic CO_2 contents, natural and petroleum-based hydrocarbons, and chemical speciation in the marine environment. Instruments available included auto-analyzer, salinometers, pH meters, oxygen titrators, double-beam spectrophotometer, infrared spectrophotometer, gas chromatograph, high pressure liquid chromatograph, infrared gas analyzers and polarograph.



TRANSPAC-72 Expedition on CSS PARIZEAU from Tokyo tp Victoria (October-November, 1972) studied the marine CO_2 cycle, marine hydrocarbons and other chemical oceanographic properties in the Pacific Ocean. Shaded area indicates surface waters with high oil aggregate contents.

TRANSPAC-72 expedition

The Division carried out a 24-day expedition along 35°N in the Pacific Ocean from Tokyo (October 10, 1972) to Victoria (November 2, 1972) aboard CSS PARIZEAU. The scientific objectives were (1) to estimate the seasonal invasion-evasion of CO_2 over large areas of the Pacific ocean and its control by the carbonate chemistry of the surface mixed layer, (2) to study the deep circulation in the North Pacific and (3) to estimate the quantities of oil aggregates and dissolved organics in the surface waters. Parameters observed included pCO_2, total CO_2, alkalinity, T°C, salinity, radiocarbon, silicate, phosphate and nitrate. The chemical data from 19 oceanographic stations to a depth of 4500 m are being processed. Preliminary data of the oil aggregates and plastics, collected by Mr. Green using a neuston net sampler, show high concentrations of oil aggregates in the western Pacific ocean between 150°E to 170°E, while negligible amounts are present in the eastern Pacific and along the coast from Santa Barbara to Victoria. This suggests a similarity in oil aggregate distribution for both the Pacific and the Atlantic oceans, with high concentrations inside the western sub-tropical gyres. Further experimental work on the chemical composition, age and the biological habitats of these aggregates is being pursued.

CSS PARIZEAU was open to the public October 4-9, 1972 at the Harumi Pier, Tokyo,in support of Canadian participation at the Ocean Development Exhibition. Visitors included the Japanese Minister of the Environment, Japanese industrialists and scientists, the Chinese and other delegations to the 2nd International Ocean Development Conference. During the stay in Tokyo, the scientific party paid official visits to the Sagami Chemical Research Center and Ocean Research Institute at Tokyo University.

Chemical Monitoring Program at Station "P"

Long-term trends of chemical parameters at weathership Station "P" (50°N, 145°W) were monitored. Weekly samples of atmospheric CO_2, surface alkalinity and total CO_2, and surface radiocarbon samples were collected to follow the secular air CO_2 increase over a marine environment and its regulation by the carbonate chemistry of the surface mixed layer. Daily nutrient samples were collected for shore-laboratory analyses with a Technicon autoanalyzer to provide information on long-term nutrient fluctuations in relation to circulation and marine food chain.

Marine Hydrocarbons

The occurrence of petroleum-based hydrocarbons in the marine environment is an area which needs long-term investigation and a capability to detect the very low levels present. Dr. Cretney is setting up a contaminant-free laboratory for the application of gas chromatographic and high-pressure liquid chromatographic techniques to the rapid separation and identification of petroleum residues and natural hydrocarbons. Mr. D. Green, a Ph.D. graduate student from the Resources Department of UBC, has been working on the distribution and fate of oil aggregates (commonly called tar balls) in the marine environment. In addition to the TRANSPAC-72 cruise, Mr. Green

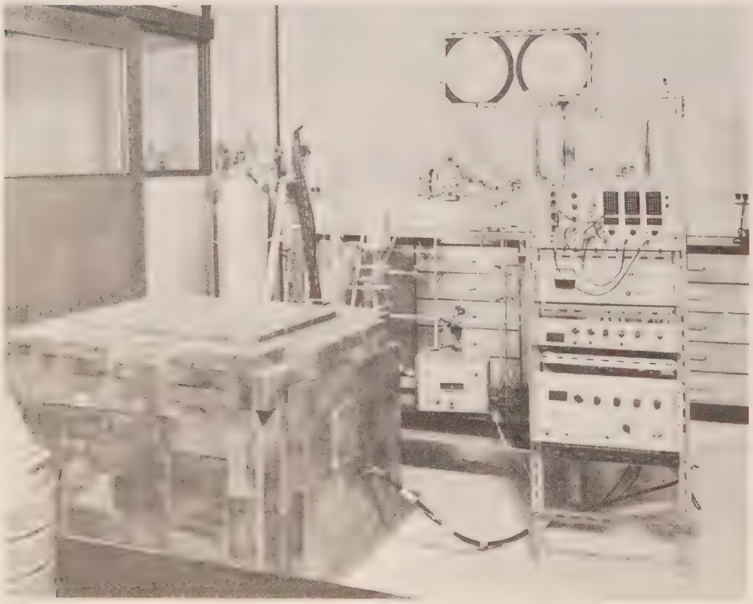
conducted a 3-day search for the presence of oil aggregates in the surface waters of the Strait of Georgia during December 1972. No aggregates were found. This negative result may indicate a clue to the origin of such aggregates: bilges from ships and tankers rather than from coastal communities. This suggestion requires confirmation.

Trace Metals

The objective of the trace metals program is to assess the natural and anthropogenic inputs of physiological significant trace metals into the marine environment, with special reference to coastal and marine waters. Dr. D.J. Francis, a NRC post-doctoral fellow, has been developing an anodic stripping voltametric technique for the analysis of lead, cadmium, copper and zinc in sea water and an ultraviolet spectrophotometric method for mercury. The important problem of the pathways of lead in the marine environment is being investigated by Mr. P. Berrang using mass spectrometric technique, in a cooperative Ph.D. thesis program between the Chemistry Department of the University of Victoria and the Ocean Chemistry Division.

Marine CO_2 Budget

Radiocarbon dating technique is perhaps the most important geochemical tool ever discovered and is of increasing applications to archaeology, geology, geochemistry, metereology, oceanography and pollution. Part of the effort in the Marine CO_2 budget program is devoted to radiocarbon measurements, essential in the understanding of the CO_2 cycle in nature, especially the air-sea CO_2 exchange rate, the speed of deep water movements and the rate of mixing from surface into deep waters. A radiocarbon laboratory at B.C. Research is being set up under the supervision of Dr. A.B. Cornford, and is expected to be in routine operation within a few months.



Ocean Chemistry Radiocarbon Laboratory located at B.C. Research, Vancouver, will be used for studies of air-sea CO_2 exchange rate, speed of deep water movement and rate of mixing between surface and deep waters.

The invasion and evasion of CO_2 in seawater is another aspect of the marine CO_2 budget program under investigation. To measure the partial pressure difference of CO_2 between air and surface ocean, an automatic measuring system for shipboard use during the TRANSPAC-72 expedition was constructed. Preliminary data indicated that along $35^{o}N$, the same track as the Scripps LUSIAD Expedition showing oceanic CO_2 undersaturation in May-June 1972, the surface waters now showed supersaturation in winter months. This demonstrates the importance of time-series measurements for oceanic CO_2 and for such purpose, two of these automatic systems will be installed on the weatherships in 1973-74.

The Neuston-Net surface sampler used in collection of oil aggregates and plastics during the TRANSPAC-72 cruise. The sampler was towed for 20 minutes at 4 knot, at 37 stations from Tokyo to Victoria. Oil aggregates ("tar balls") were plentiful in the western Pacific but rare in the eastern Pacific.

OCEAN PHYSICS DIVISION

P.W. Nasmyth, Head

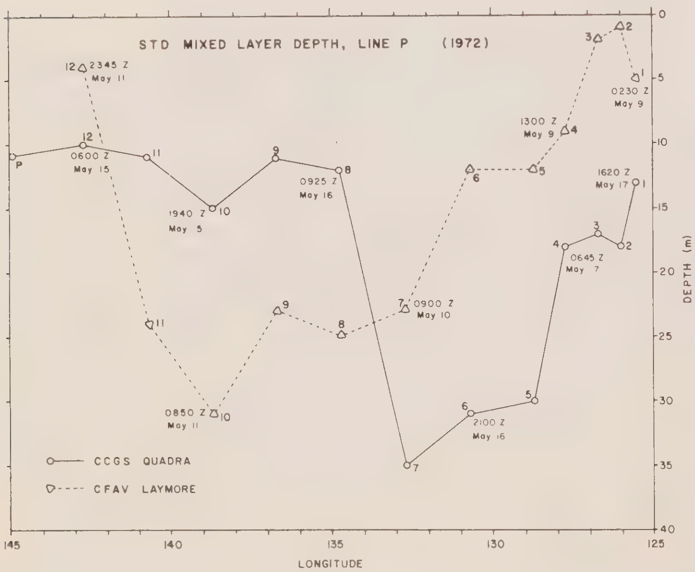
The Ocean Physics Division has increased to 37 permanent scientific and technical personnel of which 15 are professional scientists. Distribution of effort in the division has changed only slightly during the year, but the changes that have taken place may be indicative of future trends. There has been a significant increase in remote sensing, numerical modelling and in the oceanography of the coastal zone, all related in some degree to pollution and ecological problems of the Canadian west coast. An intensive but short term study of the physical limnology of Babine Lake, undertaken as a contribution to a multi-disciplinary study of the lake, has absorbed a substantial amount of effort. This program will continue through 1973, when the resources will be re-assigned to further increase the level of effort in the coastal zone, probably with some shifts of emphasis to the Arctic.

Physical arrangements for housing the division are still less than satisfactory. Locations occupied have now increased to a total of seven, of which five are in or near Victoria, one is in West Vancouver and one in Vancouver. The overall efficiency of operation inevitably suffers.

Activities of the division are reported separately by Section.

OFFSHORE OCEANOGRAPHY SECTION

J.F. Garrett, Head
S. Tabata
R.E. Thomson
D.B. Smith
K. Abbott-Smith
C. De Jong
B.G. Minkley
W. Hansen

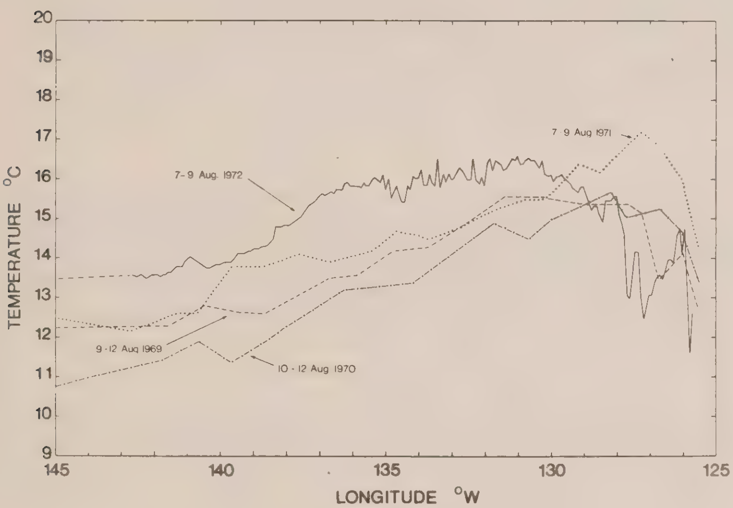


Variations over 4 to 8 days of the depth of the wind-mixed layer along Line P. The values mark the depth at which the first sharp decrease in temperature of the water occurs when measured downwards from the ocean surface.

Our efforts to understand oceanic water motions and physical processes leading to modifications of ocean water properties have diversified during 1972 as may be seen from the following brief descriptions of our activities.

Weathership Oceanography. The oceanographic time series at Ocean Station P (50°N, 145°W) was continued for the sixteenth year, with oceanographers from Offshore Oceanography or Ocean Chemistry aboard all but one of the nine patrols during 1972. The resulting data reports bring the number of volumes in the series to 54. (Garrett).

Sea Surface Temperatures along Line P. As well as bathythermographs and continuous depth profiles of temperature and salinity, sea surface temperatures are routinely observed along Line P between Swiftsure Bank and Station P by the Canadian weatherships. For most cruises temperature data from engine intakes are available as well as "bucket temperatures" and bathythermograph data. These data may be used to describe the ocean climate, to examine the variability of ocean temperatures with respect to time and distance along the Line, to interpret upwelling and water movements off the coast and to provide monitored data for fisheries and defence purposes.



There is a strong correlation between the albacore tuna catch and the distance from the coast over which the water temperature is greater than 15°C. The figure shows sea surface temperatures between the Strait of Juan de Fuca and Ocean Station P (50°N, 145°W) for the past four summers. The continuous temperatures for 1972 are based on engine intake, approx. 3 m below the sea surface, while the others are from bucket samples.

The record catch of albacore off the coast of British Columbia in the summer of 1972 has raised the question of whether or not their abundance was related to unusual oceanographic conditions. The albacore is known to be distributed in oceanic waters with surface temperatures in the range of 14-23°C but are caught generally in waters whose temperature is in a narrower range, 15-21°C. Although it is not uncommun to encounter sea surface temperatures exceeding 15°C off the Pacific coast of Canada during summer months, the occurrence of water whose temperature was greater than 15°C was much more widespread in the summer of 1972 than in the past few years, occupying approximately 400 miles along Line P. During 1971, 1970 and 1969 such warm water was found for 260 miles, 140 miles and 200 miles, respectively, while the albacore catch was 7.6, 3.7, 1.6 and 2.5 million pounds in these respective years. Although this would yield an apparently linear relationship, the picture is complicated by variations in fishing effort and skill. (Tabata).

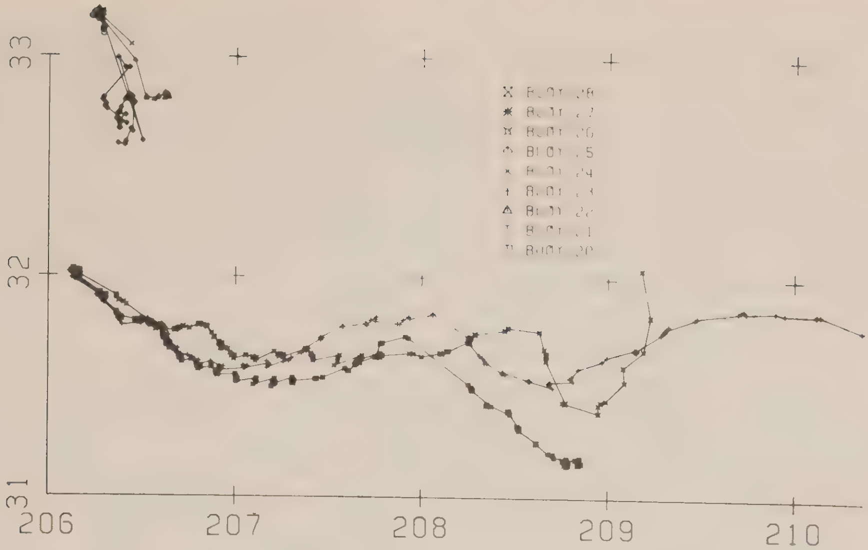
Representativeness of Line P sampling. In May an exploratory cruise to measure salinity-temperature profiles of various stations between Swiftsure Bank and Station P was made on CFAV LAYMORE in conjunction with the exchange of the weatherships CCGS QUADRA and CCGS VANCOUVER. Preliminary results using data from the three ships indicate large temporal changes of properties within the two-week period as well as large spatial differences between regions north and south of Line P. It is hoped that a new understanding of the meaning and representativeness of the historical Line P data will be obtained from further studies of this type. (Thomson).

Oceanic Noisiness. A study of the noisiness or high frequency variability of the temperature-salinity profiles obtained along Line P since 1970 by the weatherships is underway. It is hoped that this will substantiate the conclusion drawn from strictly visual inspection of the data that indicates the ocean along Line P is noisier over rough terrain than over smooth abyssal regions. (Thomson).

Energy and Energy Flux in Planetary Waves. A theoretical study aimed at increasing understanding of the effects of bottom topography on water motions indicates that the energy and flux of energy associated with planetary waves (which may be thought of as slowly varying large scale current patterns) is conserved within a closed ocean basin of any shape and bottom topography. Furthermore, it has been demonstrated that there is in fact a potential energy associated with these waves as a result of the earth's spin and depth changes.

Preliminary results for the bottom topography of the eastern side of the North Pacific indicate a slowing of planetary waves by the rough, nearly random bottom terrain. Also it appears that such waves may gain or lose energy through interactions with the bottom depending on their orientation relative to the depth contours and to the north. Work is continuing on this subject. (Thomson).

Cobb Seamount: The influence of topography on local water properties. After a cruise aboard CFAV LAYMORE to investigate space-time variability in the region of Line P indicated a pattern in the distribution of water properties apparently related to Cobb Seamount, two further cruises were made in an attempt to detect "wake" disturbances about the seamount. Preliminary results indicate a depth persistent distortion of the density field in the vicinity of the seamount which could be attributable to flow past this obstacle. Complementary weathership and U.S. Coast Guard observations at the time of the first LAYMORE cruise have also given a spatial picture of the temperature distribution with depth between the seamount and the B.C.-Washington coast. (Thomson).



Tracks of drifting buoys obtained by means of the French EOLE satellite. The coordinates are north latitude and east longitude. The interval between the clusters of positions along the track of each buoy is one day. Successive positions within the clusters are 100 minutes apart.

<u>EOLE Buoy Project</u>. In a cooperative venture with the Laboratoire de Météorologie Dynamique, of the French Centre National de la Recherche Scientifique, nine drifting buoys were launched from CFAV LAYMORE about 600 miles north of Hawaii at the beginning of February. Attached to large square sails or drogues at a depth of 25 m, these buoys were tracked by the French EOLE satellite. The object of the experiment was to study the rate of horizontal dispersion of disturbances of the oceanic mixed layer. Although all the buoys failed within a month, enough data was obtained from the three which lasted longest to provide estimates of the dispersion rate. The somewhat disappointing failure rate is attributed to the fact that this was the first attempt to use the EOLE remote platform electronics, which was designed for use on balloons in a meteorological experiment, in buoys. (Garrett).

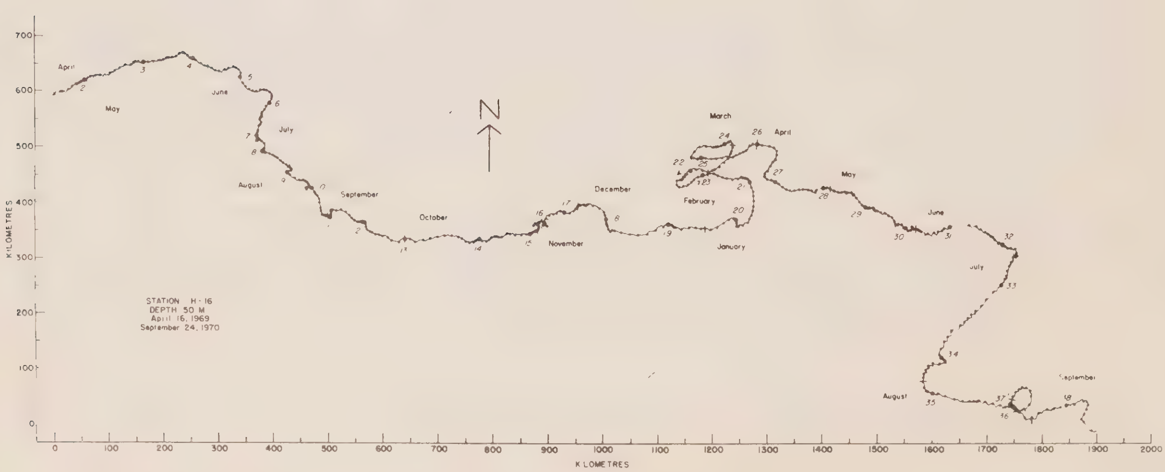
<u>Vorticity Mixing</u>. A theoretical study of vorticity mixing in the ocean has resulted in a general law governing the conservation of vorticity within an ocean and the refutation of an established theory on forces arising from vorticity mixing. (Stewart and Thomson).

<u>Current Velocity and Water Temperature in the Strait of Georgia</u>. All the current velocity and water temperature data obtained from a line of 3 moored buoy stations between Valdes Island and Point Grey during 1968 through 1970 have been processed, summarized and reported in four volumes of data reports. For each of 83 sets of measurements made at 10 or 15 minute intervals over periods ranging from 3 to 8 weeks, the summary contains histograms of current speed, current direction, current direction in polar representation and temperature, as well as a progressive vector diagram of current velocity.

A preliminary examination of the data indicates that significant non-tidal currents are present. Along the eastern side of the Strait a persisten northerly flow of about 5 km/day is superimposed on the tidal current. A net northerly flow of about 2 km/day is present in the deeper levels (200 m) in the centre and at the western side, but is less well defined than on the eastern side. At 500 m on the western side there is a northerly set with an average speed of about 4 km/day, but at the corresponding depth in the centre the set is eastward, at about the same speed. The presence of these net currents has significant bearing on the transport of materials such as pollutants and low mobility marine organisms. (Tabata).

<u>Longshore Currents Generation by Internal Waves.</u> The persistant northward flow just off the Fraser River delta and Point Grey, which has been seen in current meter and drifting drogue observations as well as aerial photographs of the silt distribution, appears to result from something other than wind or tidal effects. New theoretical work indicates that this current might result from the breaking of internal waves in shallow water, since in Georgia Strait these waves have the proper directionality and energy to generate such flows. (Thomson).

<u>Georgia and Juan de Fuca Straits Data Catalogue.</u> A catalogue listing all discoverable physical oceanographic data for Georgia and Juan de Fuca straits, giving indexes by areas and listing possible composite time series is nearing completion, and will be available early in 1973. A companion volume on biological oceanographic data possible relevant to water quality is also being prepared. (Garrett).



The displacements due to current velocities near the centre of Georgia Strait were observed at 15-minute intervals over a period of 17 months. Although the net velocity is to the east, flows in other directions occur for periods long enough to be significant from the point of view of effluent movement and disposal.

COASTAL ZONE OCEANOGRAPHY SECTION

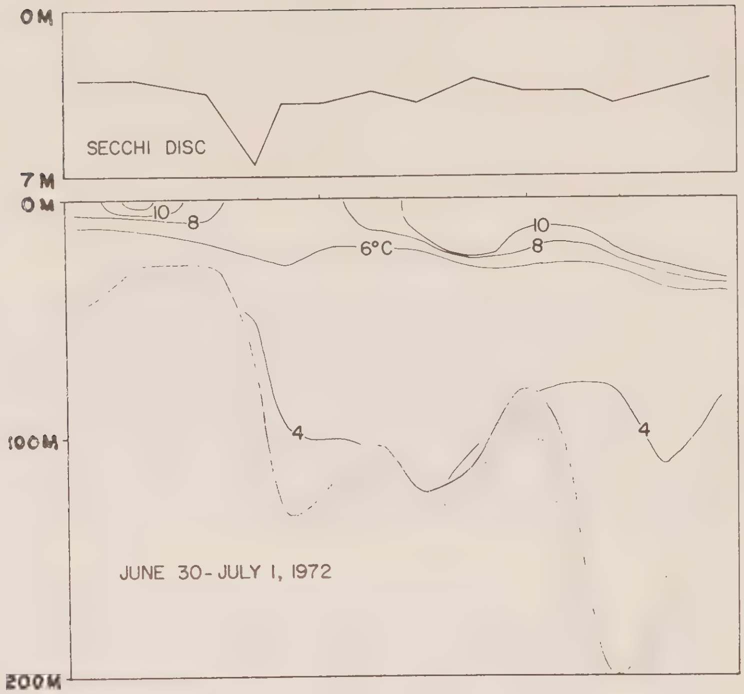
D.M. Farmer, Head
L.F. Giovando
W.H. Bell
R.H. Herlinveaux
R.E. Johns
H. Hollister
J.A. Stickland
R.H. Bigham
L.A. Spearing
K.A. Gantzer
J.A. Meikle
R.E. Forbes
E. Wilson

This year the resources of the oceanographic section, West Vancouver, were used to form a new group called "Coastal Zone Oceanography". The purpose of this section is to study oceanographic problems along the B.C. coast and in the Arctic. In addition, a program to study Babine Lake was undertaken in 1972 in response to a request from the Fisheries Research Board. Together with a number of other DOE projects in the area, the work is being conducted within the framework of the "Babine Lake Steering Committee". The section has also continued to provide physical oceanographic support for the Fisheries Service programs undertaken by the Pacific Environment Institute.

Babine Lake Project. The purpose of this project is to provide a background of physical limnology necessary to the proper interpretation of biological and chemical studies in the area. The scientific investigations in Babine Lake of which our physical study is part, are motivated by concern for the future of the salmon fishery and especially the recently constructed spawning channels, in the face of a changing environment. The observation program began in May 1972 and consists of a succession of bathythermograph stations taken throughout the lake (twice a week along the major axis), and the monitoring of winds, currents and temperature profiles with recording instruments. The BT program has logged some 12,000 miles and produced a detailed commentary on the lake's changing thermal structure. These efforts have revealed the existence of areas of upwelling, an unexpected form of autumnal cooling and the time and space dependence of wind-mixing. It is evident that orographically induced wind divergence is a fundamental significance to the lake's dynamics; the deployment of additional anemometers to measure it is central to the 1973 program.

Processing of current meter and thermistor chain data has been hampered by the failure of tape translation equipment. Initial data processing has shown a number of interesting features such as wind-mixing, thermocline development and the complex patterns of wind drift, barotropic currents and other dynamic events in the lake. The Black Point current measurements will continue through 1973 and should provide considerable insight into the exchange processes occurring between the two major basins of the lake.

The success of this project is in large measure dependent upon an appropriate method for handling and storing data. The system is set up to store and retrieve data from any number of instruments in chronological order, on a 10-minute time base. This time base represents our highest sampling frequency, all recording instrument clocks are synchronized. It is thus a simple matter to retrieve data from any combination of instruments over a specified period for further processing such as contouring or time series analysis.

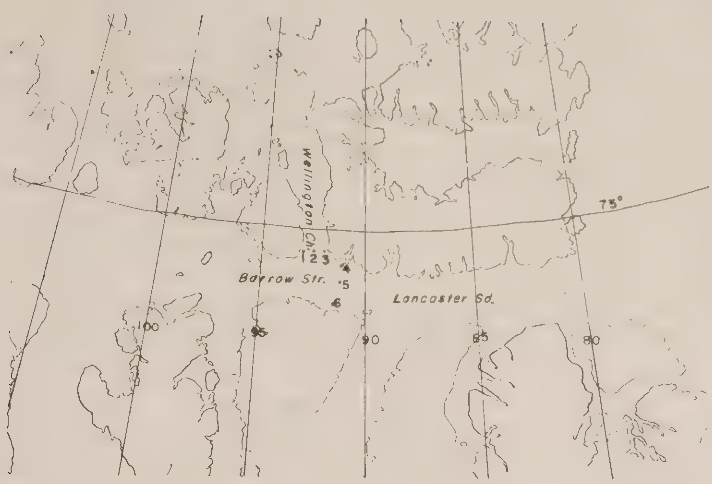


Temperature section of Babine Lake showing the correspondence between transparency (secchi depth) and upwelling.

During the winter of 1972-73 temperature observations will be taken through the ice in addition to measurements from subsurface moored instruments. During 1973 we hope to integrate the physical program with a biological productivity project. The observations will terminate at the end of 1973. (D. Farmer).

Howe Sound Project. A program of oceanographic data collection was established in Howe Sound, a fjord-type estuary adjoining the Strait of Georgia. Two buoys, with instruments for measuring water currents and temperature at four depths, were maintained in the southern half of the main channel for most of the year. In November, they were moved into the northern half of the Sound. Two hydrographic station cruises were undertaken, in February and June. Data reduction routines were established and a start was made on assesing the oceanographic features implied by the data. (W. Bell).

Arctic Oceanography. A much reduced oceanographic program was carried out in the Arctic this year due to the limited amount of icebreaker time made available. However, oceanographic stations were taken across the channel in Wellington Channel and Barrow Straits. Samples from these stations were frozen and taken back for nutrient sample analysis by the Fisheries Service.



Positions of oceanographic stations occupied in September 1972.

Plankton samples were collected for analysis by the Environmental Protection Service. Bottom samples were collected to provide background information and will be analyzed for their biological make-up and metal content by the Fisheries Research Board. At each oceanographic station a current-speed profile was attempted to determine the shear zones across Wellington Channel, Barrow Straits and Lancaster Sound. The main velocity shears appear to be around the 10 m depth (ice thickness about one foot). Light transmission properties were observed down to 80 m in the blue-green (BG12) and red-green (RG1) ranges at several locations. A report will be prepared when samples analysis is complete. (R. Herlinveaux).

Strait of Georgia. Data obtained in the Five Finger Island area near Nanaimo, B.C., for use by the Greater Nanaimo Sewerage and Drainage District in the placement of a new sewage outfall have provided insight into currents in the area. The use of surface drogues confirms that shallow motion, in the general area shoreward of Five Finger Island and to the southeast, is a complicated function of wind, tide and "shoreline" characteristics. By the same means surface net motion somewhat seaward of the proposed outfall site appears to be essentially east or southeastward.

The current profiling indicates that subsurface ebb currents are generally southeasterly and between 0.2 and 0.4 knots. The corresponding flood currents are of the same order in speed but the current direction fluctuates much more. The net movement, however, is generally southeasterly. Such movement is essentially confirmed by the 6-week series of current readings, which indicate easterly or southeasterly movement for up to three weeks or so at a time. Several day periods of quite restricted motion are also found. Net movements of the order of 10-20 cm/sec can occur over 1-2 months. This suggests the prevailing movement of water (both surface and subsurface) from the proposed site of the outfall is toward Gabriola Island. (L. Giovando).

North Pacific Surface Temperatures. A study has been made of the basic characteristics of Canadian and Japanese monthly mean sea-surface temperature data obtained by merchant shipping in the general vicinity of the present Ocean Weather Station P (50°N, 145°W) during the period 1927 through 1933. About two Canadian (thermograph) readings per month were involved; these data have not previously been reported. Each Japanese (bucket) mean monthly value included several readings within the two "5-degree" squares north of "P" and cornering on it; the values represent a portion of a data series collected from 1911 through 1938.

The agreement between the two sets of data appears generally good - in spite of the fact that the Canadian data were obtained in a different manner and were much less numerous than were the Japanese, and that the two data sets were processed independently. An annual oscillation is clearly evident in both cases. The results suggest that this oscillation is more consistent between the two sets than is the mean -- and appear to be in general agreement with those obtained from similar investigations carried on elsewhere. The consistency between the two sets for the period 1927-33 would appear to enhance the value of both entire sets, especially the Japanese (because of its greater length), as "pre-weathership" contributions to an examination of the oceanic climatology of the North Pacific. (L. Giovando).

Laying a current meter in Babine Lake with the F.R.B. seiner TAHLOK.

Squamish Estuary Study. A review of the physical oceanography of the Squamish Estuary area, at the head of Howe Sound, has been prepared. This was done for the Federal-Provincial Task Force on the Squamish Estuary Harbour Development.

Oceanographic data, especially those upon water movements, are scanty, but some conclusions can nevertheless be indicated. A typical horizontally layered water structure exists in the area, being characterized by the predominant salinity structure generated by the runoff from the Squamish River. Surface currents near the mouth of the river are strong and basically southerly in the summer, the freshet providing speeds of up to 3 knots or more. The surface movement in the eastern portion of the estuary area are much more modest. The appearance at times of a counterclockwise movement in the eastern portion is suggested. Movement decreases in magnitude with depth; below 2-30 ft speeds are very small and comparable throughout the area; no marked preference for direction appears to exist. The surface movements noted above appear in general to be qualitatively confirmed both by examination of aerial photographs of the silt-laden river water and by movements of free-floating drogues.

A further, shorter report on the Manquam Channel, at the eastern side of the Squamish delta has been prepared as a supplement to the above report on the Squamish estuary. (L. Giovando).

Daily Oceanographic Observations in 1972. In 1972, surface oceanographic observations were made daily at 16 shore stations along the B.C. Coast. The observation consists of a sea surface temperature and the measurement of the seawater density by a hydrometer.

During the first 6 months of 1972, the monthly mean sea temperatures were significantly below normal at the stations along the northern mainland and ocean coasts. Temperature conditions were near normal during July and August with the exception of above normal temperatures in August at Langara Island and Amphitrite Point. In September below normal conditions again prevailed and continued into October.

At the stations in the Strait of Georgia, sea temperature trends varied from month to month, but below normal conditions were more frequent. A normal trend in the monthly mean sea temperatures during the first 3 months was interrupted by significantly below normal temperatures in April. A brief normal period in May and June was again halted by below normal conditions in July. Above normal temperatures occurred in August, followed in September by a return to below normal temperatures which also prevailed in October.

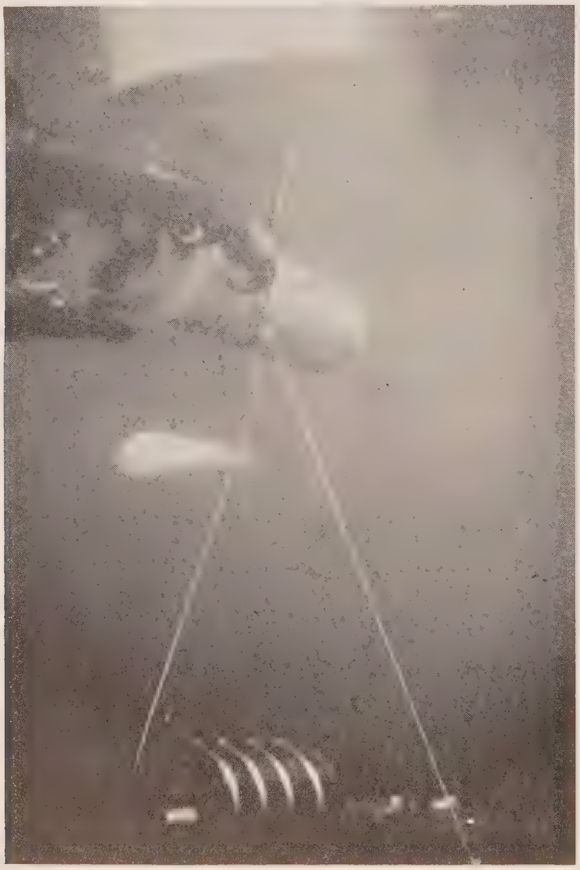
Monthly mean salinities at the stations on the ocean coast and in Hecate Strait were often below normal during the spring and summer months. This can be associated with excessive river discharge and higher than normal coastal precipitation amounts during the same period. Normal conditions prevailed during the winter and fall.

At the Strait of Georgia stations the salinity conditions were generally near normal. The most notable exception was the occurrence of below normal salinity at Entrance Island and Cape Mudge in June, because of the high Fraser River discharge. (H. Hollister).

Computing Services. In addition to the multichannel data storage and retrieval system developed for the Babine Lake project, programs have been written for data presentation of various types including Progressive Vector Diagrams, Histograms, Contours and Time Series Plots. A teletype and fast card reader link up to the UBC computing centre has been established. Programming support has also been provided for FRB personnel at PEI. (R. Johns).

Associate Research. A review has been commenced of oceanographic data from the eastern Beaufort sea with a view to interpreting distribution in the light of modern mixing theory. The earlier work on inlet dynamics has been extended to include a net seaward volume transport, thus providing more realistic landward boundary conditions. The dynamic implications of this refinement have not yet been explored.

On the invitation of the United States National Science Foundation, Dr. Cameron attended an international symposium in Hokkaido, Japan and presented a paper on the budgetary aspects of circulation schemes for the Bering Sea. (W.M. Cameron).



Divers installing Bass tide gauge in Brentwood Bay, B.C.

OCEAN MIXING SECTION

P.W. Nasmyth, Head
A.E. Gargett
G.W. Chase
R.C. Teichrob

The study of turbulent mixing in the ocean has continued through 1972, with a 5-week experimental operation during January-February in the region southwest of Cape Flattery and out as far as Cobb Seamount. Data from that operation are not yet completely analyzed but a significant qualitative result is that both the occurrence of intensity of turbulence were very much lower than has been observed in part of the same area and at the same time of year on previous occasions. Earlier measurements have indicated that, on the average, approximately 20 percent of the total volume between the thermocline (approximately 75 m) and our maximum depth of 300 m was turbulent. In the latest experiment only something like 1 percent of the total volume contained detectable turbulence.

At this time we have no satisfactory explanation for the difference. A possible factor may be that the weather was unusually good this year with less wind and lower sea state than normally expected during the winter months. The observed result then may lend strength, in a negative sort of way, to the idea that, even far below the thermocline, turbulence may be generated by indirect effects of surface wind and the resulting sea state.

A few pieces of record from the platinum velocity and temperature sensors have been analyzed, but results are not always convincing, due to one or both of two factors, the general low intensity of turbulence observed during the cruise and the short space/time extent of those patches which did show higher levels.

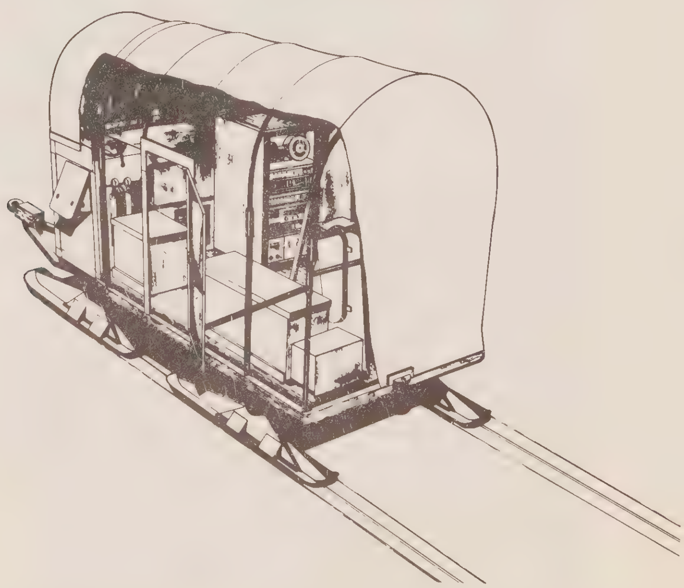
The disappointing nature of the turbulence data lead to closer examination of supporting data which is obtained from the towed body. In particular with the winch set to cycle the towed body through 100 ft in depth, time series of the thermistors and the depth gauge mounted on the body can be used to estimate the horizontal coherence of small scale temperature structure over distances up to 2 km. Analysis of all data available, on a line from Cobb Seamount (200 miles offshore) to the continental shelf, has not yet been completed.

Data from the conductivity head mounted on the body should allow similar statistics on horizontal coherence to be compiled for the vertical structures of both salinity anddensity (or associated parameters like the Väisälä frequency).

FROZEN SEA RESEARCH GROUP

E. L. Lewis, Head
J. D. Bradbury
R. A. Lake
A. E. Moody
K. Fujino (visiting scientist
Sapporo, Japan)
S. W. Moorhouse
R. G. Perkin
D. L. Richards
R. B. Sudar
J. A. Sutherland
E. R. Walker

During February and April 1972 field operations were conducted in Cambridge Bay, N.W.T. where measurements were made of the temperature and salinity of the water column beneath the growing sea ice. This completed the set of experiments begun in the summer of 1971. A study of the data from all four field operations has now been completed and a draft paper entitled "Oceanography of an Arctic Bay" is ready for submission to a journal. Of particular interest is the evidence of dense waters produced by under-ice convection running downwards from the shallows of Cambridge Bay into deeper waters. Heat and salt budgets of the bay have also been worked out, the former in terms of meteorological parameters. The rapid changes in water structure during freeze-up have been documented and include the response of the system to the wind and tidal cycles.



Complete oceanographic sled as used on Cambridge Bay 1972. The sled carries a complete recording system. CTD and other sensors are lowered by the winch at the rear through the hole in the deck which is positioned over a hole in the ice.

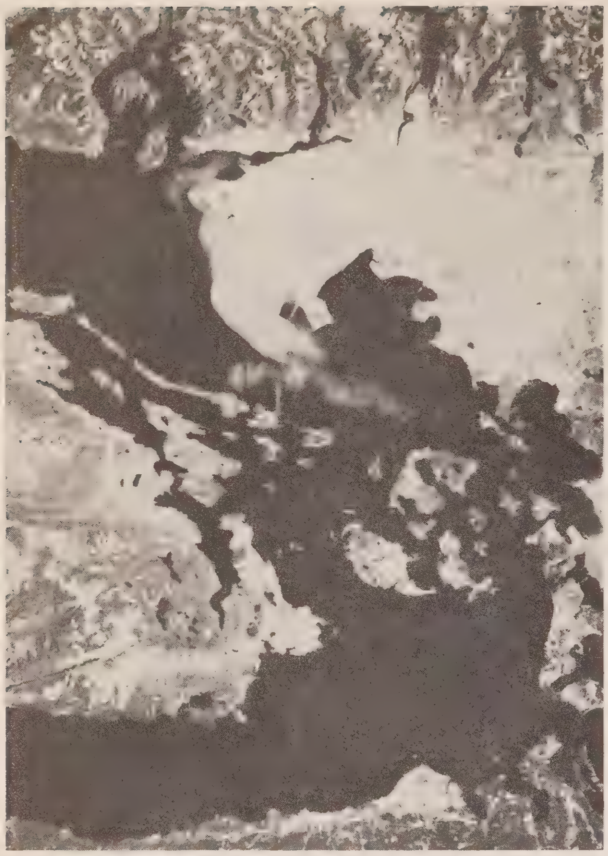
In August 1972 a tide gauge and three temperature profile recorders capable of one year's unattended operation and recording were installed in the vicinity of our Greely Fjord base (80°36'N, 79°35'W). In addition, a preliminary survey of a site to measure runoff from the land was made. Owing to the permafrost and the extreme fragmentation of overlying soil, it is necessary to pick such sites with great care as, except during peak flood conditions, maybe only one half of the runoff is visible at the surface. Oceanographic profiles were obtained which, because of the almost continuous ice cover, will give the basic density profile with which the present winter's ice growth/convective system must interact.

Experiments to determine the freezing point of sea water in the range 20-35°/oo have been completed and show values about 0.01°C lower than those presently used as standard given by Hansen[1]. Experiments are proceeding on the effect of pressure on the freezing point. A critical review of data collected utilizing our Conductivity-Temperature-Depth (CTD) system led to experiments on sensor time constants using an abrupt change of water properties produced in a vertical 25' length of 2' diameter pipe. These studies have modified our sampling procedures. We have undertaken testing of an untrasonic current meter with a potential threshold of 1 mm/sec and have started some study of sonic direction determination for use with it in Arctic waters where the earth's magnetic field is too nearly vertical to be much use. Some modifications to our existing mechanical equipment used for making oceanographic measurements for over-ice traverse are being made as a result of experiences at Cambridge Bay where on one day in February the wind chill reached the equivalent of -115°F.

The tide gauge designed by the group has now gone out to industrial production and another company is starting a "systems" section to develop and market CTD measurement and recording equipment based on our designs.

An Arctic Fjord Workshop attended by 15 delegates from four countries took place July 5-7, 1972. Dr. H. G. Gade of the Geophysical Institute, University of Bergen, worked with us May-July on the interpretation of the Cambridge Bay data.

[1] Hansen, H.J., Experimental Determination of the Relation Between the Freezing Point of Seawater and its Specific Gravity at 0° C., Meddelelser Fra Kommissionen for Havundersøgelser, København, Serie: Hydrografi, Bind I, Nr. 2, pp. 1-10, 1904.



American ERTS-1 satellite picture of the Vancouver area taken from a height of 600 miles at 1040 July 30, 1972 on an ebb tide at a time of relatively high Fraser River discharge. The silt in the river water makes the delta coastline hard to distinguish. The geometry of the plume can be seen down to very low contrast levels when the photograph is electronically enhanced.

Pictures such as this will be available from the Canada Centre for Remote Sensing for all of Canada to 82° north and out to several hundred miles off shore.

REMOTE SENSING

J.F.R. Gower (under contract)

A report on a literature survey of the uses of remote sensing from aircraft and satellites in oceanography and hydrography was distributed in January 1972, and since then an experimental program has been started to test some of the ideas and techniques.

Some of these tests involved the use only of commercial equipment and charter aircraft (Sippican XBT test, Boeing LRPA exercise), others were carried out using the facilities of the Canadian Centre for Remote Sensing (high level aerial photography, satellite photography) and one involved development of a system to be flown in a commercial charter aircraft (infrared surface temperature measurement).

In general, the most widely used remote sensing technique is aerial photography. The Canadian Centre for Remote Sensing has a wide capability for applying modern photographic techniques for evaluation purposes, and one of the duties of the remote sensing consultant has been to help other workers make use of the CCRS facilities and to advise CCRS on other possible applications. Photography over the Fraser River Plume in the Strait of Georgia and over Babine Lake was ordered during the year.

A new development has been the availability of space photography of all of Canada (to 82°N) from the US ERTS-1 satellite. The CCRS is reponsible for processing and distribution of Canadian pictures and considerable coverage has been ordered from them of B.C. and the Canadian Arctic. The resolution (about 60 m) has been found sufficient for silt motion and ice and snow cover studies. The multiband pictures also give a very stable colour rendition which allows small water colour changes to be detected.

After aerial photography the next most widely used remote sensing technique is now thermal infrared imaging. The CCRS has concentrated on high resolution work emphasizing temperature variation but for oceanography, lower resolution measurement of surface temperatures is often more useful. An improved (narrow band) version of the PRT-5 radiometer was purchased during the summer and built into a system to be flown in a Beaver floatplane. The system allows continuous in-flight calibration and output recording on paper chart and magnetic tape. A test flight over Babine Lake showed that an accuracy of 0.2°C is quite feasible and that the radiometer can be set up to scan 35° either side of the nadir. Further flights over the Juan de Fuca Strait and Babine Lake are planned for next year.

Various other techniques that have applications more specifically to oceanography were also investigated. A joint experiment with the Boeing Aircraft Company's prototype Long Range Patrol Aircraft (a highly instrumented Boeing 707) was carried out to investigate the feasibility of wind velocity and surface current measurement by comparing navigational data from a doppler radar and from an inertial navigation system. It turned out that the doppler radar received insufficient return signal from the very calm sea surface on the day of the flight, although some useful data was collected. Boeing has since made other data available, and a repeat flight is also a possibility. This investigation is also being continued with a doppler radar to be flown from a rented DC-3 aircraft in 1973. The radar has been purchased and necessary modifications will be carried out by Dr. M. Miyake of IOUBC under contract.

A contract with Dr. G.A.H. Walker of the Geophysics Department, UBC, was being negotiated in December 1972 for construction and testing of a prototype water colour spectrometer. This unit would be based on an integrated silicon photodiode array from which digitized spectral intensities could be recorded on magnetic tape. Such a spectrometer should be sensitive, compact and rugged and hence ideal for airborne work in water quality and productivity studies.

Expendable sensors that can be dropped from aircraft should be extremely useful in applying remote sensing techniques. In conjunction with Offshore Oceanography the Sippican wire connected XBT was tested from a Beaver floatplane and found to give useful results from low altitudes.

NUMERICAL MODELLING SECTION

P. B. Crean	L. Smith
R. F. Henry	P. Richards

To provide an understanding of the water movements requisite to efficient management, complementary numerical model and field studies of the Strait of Georgia and Juan de Fuca Strait are being undertaken. A successful tidal model has been evolved using a system of joined one and two-dimensional numerical schemes. This model is being modified to incorporate effects of fresh water runoff and winds. (Crean).

A one-dimentional model of Babine Lake was begun in order to study seiche action and to establish wind stress coefficients. (Henry).

The full line shows places at which high tide is at the same time and the dashed line places at which the high-low tide difference is the same, for the twice-a-day (M_2) component of the tide, as derived from a numerical model of Georgia Strait.

SHIP DIVISION

E.N. Geldart, Regional Marine Superintendent
F.S. Green, Assistant Marine Superintendent

Pacific Region ships provided successful support to all prescribed 1972 programs and completed their assignments without mishap or unscheduled interruptions in service.

C.S.S. PARIZEAU

Master, A.G. Chamberlain
Chief Engineer, D. Marr

Following the January 1972 annual refit in Yarrows Ltd., Victoria, PARIZEAU served the requirements of MSD (Tidal and Currents); UBC (Biology); FRB (Biology); PEI (Biology); and GSC (Geophysics) until June 5. The ship was then converted to Western Arctic Hydrographic configuration and departed Victoria on July 4 to the Western Arctic. Hydrography was performed in this area until August 31.

On September 12, following twelve days of geophysics (GSC) PARIZEAU commenced her voyage from the Western Arctic to Tokyo, Japan, where she attended the International Ocean Development Conference. During the voyage from Tokyo to Victoria the functions of MSD Ocean Chemistry were performed. The remainder of the year was taken in converting to oceanographic configuration, ice-damage survey and annual refit. With the exception of badly damaged bilge keels and a leaking stern tube seal ice-damage was negligible.

C.S.S. WM. J. STEWART

Master, T.P. Scanlan
Chief Engineer, J.D. Henderson

Following the annual refit and winter decommission periods WM.J. STEWART engaged in Hydrographer Training from February 14 to April 29 in the general vicinity of Chemainus and Ladysmith, Vancouver Island.

During the period April 30-October 6 she carried out the regular hydrography assignments in the areas of Strait of Georgia, North B.C. Coast and Massett, Queen Charlotte Islands. The remainder of the year was occupied by annual refit and winter decommission.

C.S.S. VECTOR

Master, C.A. Macaulay
Chief Engineer, G.W. Clouston

Following the January 1972 annual refit, VECTOR served the requirements of MSD (Ocean Chemistry, Tidal and Current, Research and Development); UBC (Chemistry, Biology, Physical Oceanography); PEI (Ecology); UVic (Ocean Physiology) in B.C. coastal areas.

C.S.S. RICHARDSON

Master, C.M. McIntyre
Chief Engineer, I.N. Henderson

The overdue quadrennial refit and survey was performed on RICHARDSON in Stirling Shipyards Ltd., Vancouver. In conjunction with the pollution abatement program in DOE vessels a two-unit "Sani-vac" vacuum toilet and holding tank system was installed by Matsumoto Shipyards Ltd., Vancouver. Following MSD's acquisition of PISCES IV, RICHARDSON was assigned the role of tender-vessel to this craft.

C.F.A.V. LAYMORE

Master, M.J. Dyer
Chief Engineer, T.J. Taylor

C.F.A.V. LAYMORE was made available in 1972 to Pacific Region scientific users by way of a 75%-25% cost-sharing arrangement between MSD and DND. During this period LAYMORE served PEI (Chemistry, Ecology and Biology); Canadian Forces (Diving Unit); FRB (Ecology); MSD (Ocean Mixing and Ocean Chemistry); UBC (Equipment trials); DREP (Equipment trails); and UVic (Ocean Survival).

M.V. RADIUM EXPRESS

Master, H. Bennett
Chief Engineer, R. Green

Northern Transportation Co.'s M.V. RADIUM EXPRESS was chartered during the navigational season to support the Mackenzie River Hydrographic party. This recently refurbished vessel proved a vast improvement on last year's charter vessel, PILOT II.

PISCES IV

Chief Pilot, D. Harrison
Pilot, P.S. Legallais

PISCES IV, a deep-dive submersible craft, became the most recent addition to the Pacific fleet. It is intended to operate this craft, attended by seven seconded Canadian Forces personnel, from a chartered barge until the acquisition of a more suitable chartered mothership can be arranged. PISCES IV's operations will necessarily be restricted until this transition becomes effective.

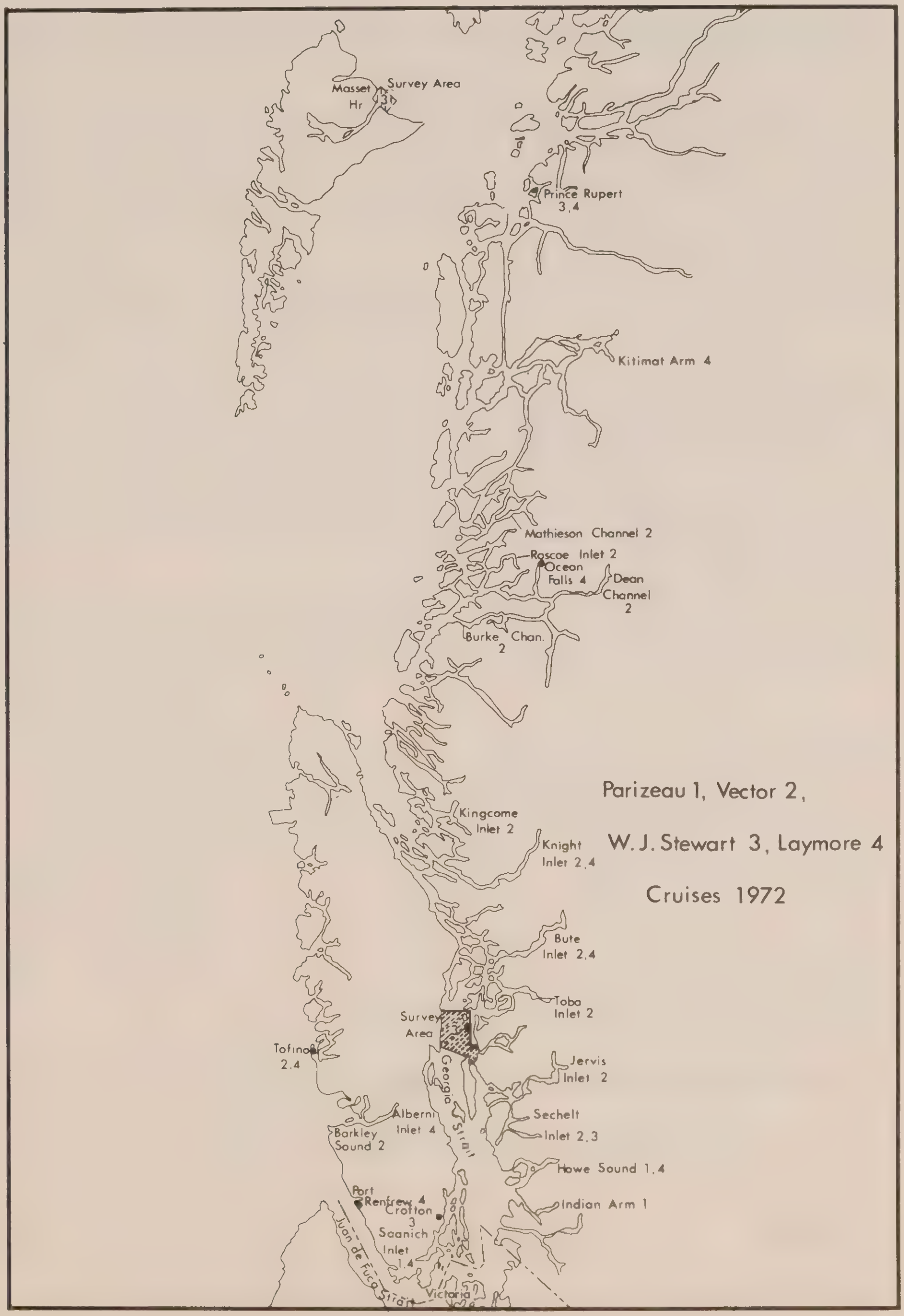
LAUNCHES

Pacific Region's twenty-five survey launches and assorted power craft performed exceedingly well and registered a minimum of down-time due to mechanical and structural failures. The new set of engines in C.S.L. REVISOR totally eliminated the multitude of mechanical difficulties previously experienced by this launch.

The Hamilton-Jet boat used in the Mackenzie River survey experienced good results except for a faulty engine which caused the hydrographers some difficulty. The fitting of a better engine and the supply of a spare engine is expected to eliminate this defect during the next season.

DEPOT

The launch repair facilities in the Victoria depot continued to contribute to the recent success in launch operations. The fortunate acquisition of good tradesmen and improved maintenance methods are considered largely responsible for this result.



TASK FORCE, COMMITTEE AND SIMILAR ACTIVITIES

Stewart, R.W.

Joint Organizing Committee (JOC) of Global Atmospheric Research Program (GARP) - Chairman.

Canadian Committee for GARP.

Advisory Committee on Oceanic Meteorological Research (ACOMR).

Physical Oceanographic Commission of IAPSO - Chairman.

Scientific Committee on Oceanic Research (SCOR) - Canadian representative.

National Research Council - Advisory Committee on Physics.

IAMAP - IAPSO - SCOR Working Group on Air-Sea Interaction.

Pacific Region Board.

The Sea Use Council (USA) - Vice-Chairman.

International Council of Scientific Union - COSPAR Committee on Space Research.

The Royal Society of Canada - Selection Committee (interdisciplinary).

Federal-Provincial Task Force on Strait of Georgia.

Water Management Executive Committee.

Steering Committee, Patricia Bay Ocean Institute - Chairman.

English, W.N.

Working Group on Abatement of Pollution from DOE Ships - Chairman.

Pacific Sub-Committee on Oceanography of CCO - Chairman.

Pacific Region Board - Alternate.

The Sea Use Council - Alternate.

Canadian Committee on Oceanography.

Coastal Waters Committee of Water Management Service. Co-chairman.

Estuary Working Group of Pacific Region Board.

Working Group on Remote Sensing for Oceanography of the CACRS - Chairman.

Steering Committee, Patricia Bay Ocean Institute.

Canadian Advisory Committee on Remote Sensing.

Comité d'Evaluation - Programme de Doctorat en Sciences de l'Eau, Université du Québec.

Hydrographic Division

Anderson, N.M.
Working Group on Remote Sensing for Oceanography of the CACRS.

Bolton, M.
Pacific Sub-Committee on Oceanography of CCO - Alternate.

National Hydrographic Survey Officers' Appraisal Board.

Canadian Institute of Surveying, Victoria Branch - Vice-Chairman.

Canadian Hydrographers Association - National President.

Steering Committee, Patricia Bay Ocean Institute - Secretary.

Sandilands, R.W.
Regional Working Group on Estuaries.

Workshop on Offshore Surveys for Mineral Resource Development.

Smithers, F.R.
Public Information Group, DOE Pacific.

Wills, R.
Survey Technology Advisory Committee, BCIT.

Ocean Engineering Division

Todd, N.A.
Steering Committee, Patricia Bay Ocean Institute.

Ocean Chemistry Division

Cretney, W.J.
Ph.D. Dissertation Committee - Mr. D. Green at UBC (Hydrocarbons).

Wong, C.S.
Advisory Committee - GEOSECS, Carbonate Chemistry Panel.

Advisory Committee - GEOSECS, Panel on Standardization of the Carbon Dioxide System.

Advisory Committee on expanding GEOSECS.

Working Group - International Commission on Water Quality.

Local Program Planning Committee - 13th Pacific Science Congress.

Coastal Water Quality Committee of MSD, Pacific Region.

Ph.D. Dissertation Committee - Mr. D. Green at UBC (Hydrocarbons).

Ph.D. Dissertation Committee - Mr. P. Berrang at UVic (Trace Metals).

Advisory Committee - National Science Foundation IDOE Project CEPEX Heavy Metals Variations in Biological Productive Systems.

Ocean Physics Division

Farmer, D.M.

Babine Lake Steering Committee.

Lewis, E.L.

Arctic Ocean Technology Advisory Committee of the Arctic Institute of North America.

Nasmyth, P.W.

IGOSS Group of Experts on Technical Systems Design and Development and Service Requirements - Chairman.

Tabata, S.

Regional Cross-Mission Task Force on Environmental Impacts of the proposed Moran Dam.

Regional Cross-Mission Task Force on Environmental Impacts of Squamish Harbour Development.

Regional Cross-Mission Task Force on the Environmental Impacts of the proposed Burrard Inlet Third Crossing.

Regional Cross-Mission Task Force on the Environmental Impacts of the Alternate Manquam Channel - Squamish Harbour Development.

Review Committee for Fraser River Delta Front Sediment Budget Study.

Science and Technology Mission to Japan: Sector IV Oceanography and Ocean Technology.

RESEARCH AND DEVELOPMENT CONTRACTS

		TOTAL AMOUNT
1.	Establish Carbon 14 dating laboratory for analysis of Oceanographic and other samples. B.C. Research. (continued from 1971).	$37,700
2.	Carry out the study of remote sensing applications to hydrography and oceanography. Dr. J.F.R. Gower. (continued from 1971).	$16,000
3.	Inform and demonstrate to Canadian scientists the Japanese approach to problems in Arctic oceanography. Dr. K. Fujino, Hokkaido University. (continued from 1971).	$12,000
4.	Study temperature and conductivity microstructure in inlets and seas as an aid to understanding turbulent mixing and transport. Institute of Oceanography, University of British Columbia. (continued from 1971).	$20,000
5.	Production and bench testing of a prototype spectrometer for sea colour monitoring. Prof. R.D. Spratley, University of British Columbia.	$1,560
6.	Conduct the first phase of a study of fjord and inlet dynamics of the British Columbia Coast (a) examine the two-dimensional structure of the currents in the surface layer in two regions; (b) examine the vertical current structure in more detail at a number of points. Institute of Oceanography, University of British Columbia.	$15,185
7.	Provide airphoto flight specifications for tide controlled photography of the Labrador Coast and offshore islands, to be designed to optimize the photographic factors in order to maximize the water depth penetration of the imagery. Airphoto Analysis Associates Ltd.	$375
8.	Provide interpretation of hydrographic data from colour aerial photographs and mapping of 35 nautical miles of shoreline in Haro Strait, Vancouver Island. Airphoto Analysis Associates, Ltd.	$8,000
9.	(a). Develop the mathematical model and related computer program for stereo-compilation of depths in shallow water from colour aerial photography. (b). Compare the accuracy of stereo-compiled depths to each sounding profiles. (c). Evaluate the effect of the operator back-ground on the accuracy of the interpretation of shallow water photography. Dept. of Survey Engineering, University of New Brunswick.	$3,864
10.	Design, test and supply two thermistor chains. B.C. Research.	$4,000

11. Furnish results of observations obtained in submersible experiments on Cobb Seamount including analysis of submersible operating problems and techniques in the open ocean. Arctic Marine Ltd. $4,500

12. Conduct feasibility study for the development of a low-cost reliable combustion engine for underwater use. Dr. E.G. Hauptmann, University of British Columbia. $14,000

13. Assist F.S.R.G. in research projects with particular reference to the application of Norwegian experience to the solution of problems in Arctic Fjord circulation and to interpret the results of Scandinavian studies in Fjord and inlet circulation systems in relation to Canadian problems, particularly winter time circulation in Cambridge Bay, N.W.T. Dr. H.G. Gade, University of Bergen. $1,550

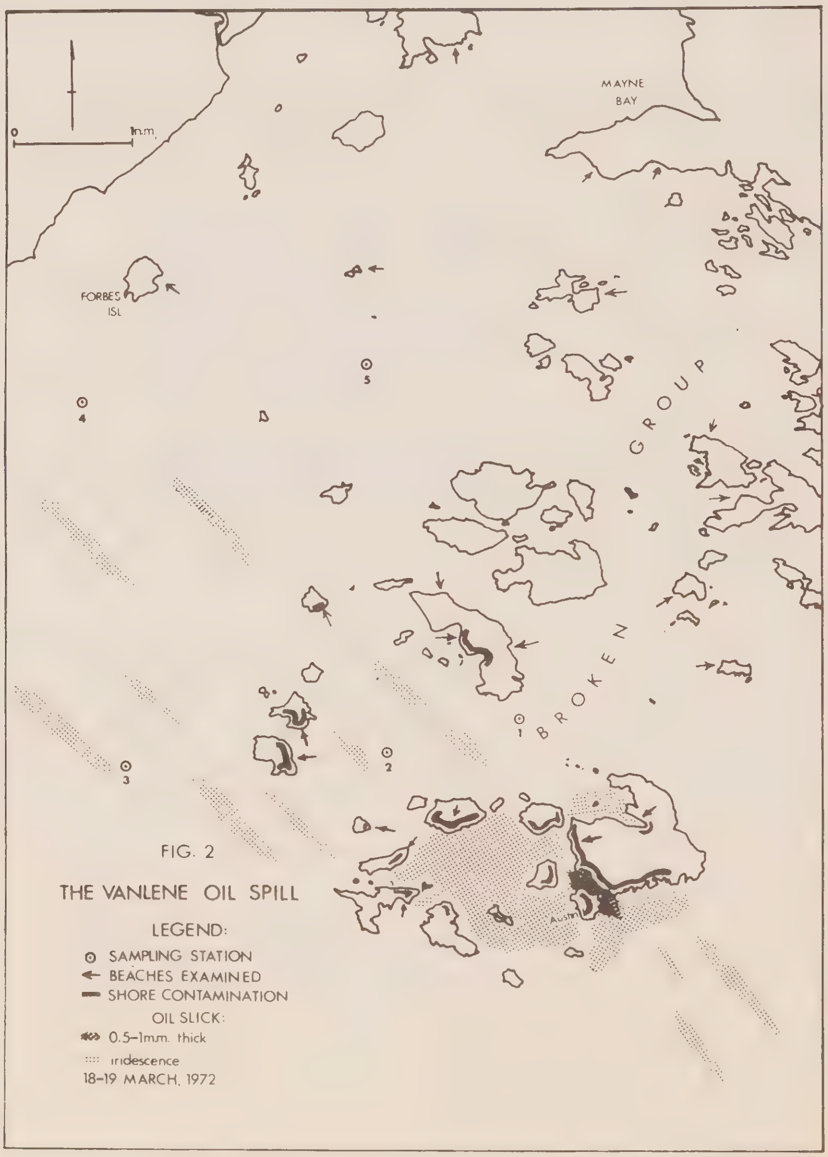


FIG. 2

THE VANLENE OIL SPILL

PUBLICATIONS

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__________________________________: Strait of Georgia Section 4, Gabriola Island to Gover Point, 1969-1972. (*Manuscript report series,* v. 10).

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PROFESSIONAL AND TECHNICAL STAFF

DIRECTOR

R.W. Stewart; B.Sc., M.Sc. (Queen's), Ph.D. (Cantab.), FRSC, FRS, D.Sc. (McGill)

DEPUTY DIRECTOR

W.N. English; B.A. (Bri.Col.), Ph.D. (Calif.)

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E.E.S. Adair
R.M. Cotton
M.I.K. Craton
R.W. Crouch
D.B. Crowell
C. Firth
J.N.J. Gravel
J.Y. Hackney
A.M. Hartley
S.A. Lyon
F.V. Mitchell
S.J. McLellan
A. Mortensen
J.E. Parsons
A.M. Robert
L.E. Thirkell
C.D. Thomas
T.S. Van Dusen
L.M. Vinden

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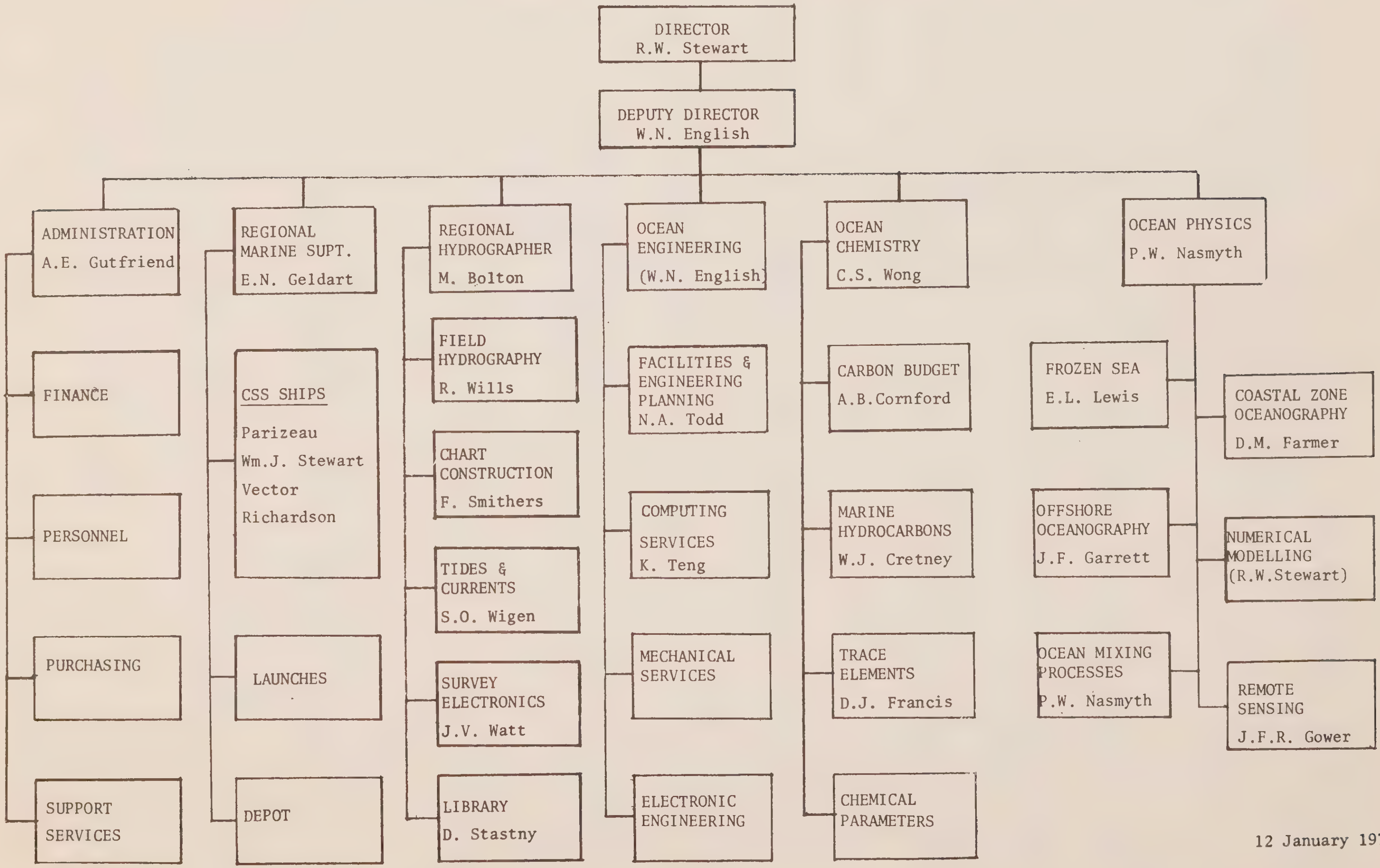
M. Bolton, Regional Hydrographer
A.B. Ages; B.A.Sc., M.A.Sc. (Brit. Col.), P. Eng.
N.M. Anderson; Dip. A.I.T.
R. Banyard
J.F. Bath; Master, F.G.
R.D. Bell
K. Bennett
R.E. Brown
P.C. Browning
I.J. Campbell
J.W. Chivas; Master, F.G.
D.J. Clark
E.B. Clarke
F.A. Coldham
J.H. Coldwell
E.M. Coulter
D.G. Dobson
L.W. Dorosh
G.H. Eaton; Dip. B.C.I.T.
N.S. Fujino; Dip. B.C.I.T.
F.V. Hermiston
K.Highton; Dip. B.C.I.T.
R.C. Hlina; Dip. B.C.I.T.
K.R. Holman
W.S. Huggett; Master, F.G.
T. Jones; Master, F.G.
L.B. Larkin
P.O. Lee; Dip. B.C.I.T.
B.M. Lusk
A.G. Lyon
C.G. McIntosh; Master, F.G.
A.R. Mortimer; Master, F.G.
C.J. Nast

ORGANIZATION CHART
Marine Sciences Directorate, Pacific Region



12 January 1973

W.J. Norris
A.D. O'Connor
M.M. Patton
A.R. Philp
R.A. Pierce
T.C. Plume
L.E. Ponse
R.D. Popejoy
W.J. Rapatz; B.Sc. (Victoria)
A.R. Raymond; Dip. Algonquin College
G.E. Richardson
G.W. Rogers
C.F. Ryan; Dip. R.R.E. (England)
R.W. Sandilands ; Lt. R.N. (ret'd)
F.R. Smithers
C.E. Stenning
C.S. Tamasi; Dip. B.C.I.T.
M.S. Taylor
W.R. Taylor; Dip. R.C.C.
L.G. Thomson
J.A. Vosburgh; Dip. B.C.I.T.
J.S. Wallace; Dip. S.A.I.T.
B.M. Watt
J.V. Watt; B.A.Sc. (EE), P. Eng. (Brit. Col.)
S.O. Wigen; B.A.Sc. (Brit. Col.) P.Eng.
R. Wills; Master Mariner, F.G.
M.V. Woods; Dip. B.C.I.T.
P.Y. Yee; Dip. B.C.I.T.
V.N. Young

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R.D. Bellegay; Dip. N.A.I.T.; Ass. Deg. (Oceanography), Shoreline Comm. College, Seattle.
A.B. Cornford; B.Sc. (McMaster), Ph.D. (Brit. Col.)
W.J. Cretney; B.Sc., Ph.D. (Brit. Col.)
D.J. Francis; B.Sc., Ph.D. (Alberta), Postdoctoral Fellow
C.M. Jackson; B.Sc. (Victoria)
P. Vandergugten; Dip. B.C.I.T.

OCEAN PHYSICS DIVISION
P.W. Nasmyth; B.A.Sc., M.A., Ph.D. (Brit. Col.); Head of Division
K. Abbott-Smith
J.D. Bradbury
W.H. Bell; B.A.Sc. (Brit. Col.), M.Sc. (Hawaii)
R.H. Bigham
C.W. Chase; Dip. B.C.I.T.
P.B. Crean; B.Sc. (Dublin), M.A.Sc. (Tor.), Ph.D. (Liverpool)
C. de Jong

D.M. Farmer; B.Com., M.Sc. (McGill), Ph.D. (Brit. Col.)
R.E. Forbes
K.A. Gantzer
A.E. Gargett; B.Sc. (Man.), Ph.D. (Brit. Col.)
J.F. Garrett; B.A. (Harvard), Ph.D. (Brit. Col.)
L.F. Giovando; B.A., M.A., Ph.D. (Brit. Col.)
H.W. Hansen; Dip. B.C.I.T.
R.F. Henry; B.Sc. (Edin), Ph.D. (Cantab)
R.H. Herlinveaux
H.J. Hollister
R.E. Johns; B.Sc. (Victoria), M.Sc. (Brit. Col.)
R.A. Lake; B.Sc. (Brit. Col.), M.Sc. (Washington)
E.L. Lewis; B.Sc., M.Sc., Ph.D. (London)
J.H. Meikle
B.G. Minkley; Dip. B.C.I.T.
A.E. Moody
S.W. Moorhouse
R.G. Perkin; B.A.Sc., M.Sc. (Brit. Col.)
D.L. Richards
P.J.W. Richards
D.B. Smith; B.Sc. (Victoria)
J.A. Stickland
R.B. Sudar; B.A.Sc. (Tor.)
J.A. Sutherland
S. Tabata; B.A., M.A. (Brit. Col.), D.Sc. (Tokyo)
R.C. Teichrob, Dip. B.C.I.T.
R.E. Thomson; B.Sc., Ph.D. (Brit. Col.)
E.R. Walker; B.Sc. (Man.), M.A. (Tor.), Ph.D. (McGill)

SENIOR RESEARCH ASSOCIATE
W.M. Cameron; B.A., M.A. (Brit. Col.) Ph.D. (Scripps)

SHIP DIVISION
E.N. Geldart; Dip. I.M.E. (London); Marine Superintendent
F.S. Green; Master, F.G., Assistant Marine Superintendent
S.S. Grypma
K.J. Sjolholm; Master F.G.; Relief Master
E. Fisher; Master F.G.; Relief Mate
B. Aaron; Engineer First Class Combined, Relief Chief Engineer
R. MacPherson; Engineer 3rd Class Combined; Relief Engineer
H.A. Ruffell

CSS PARIZEAU
A.J. Chamberlain; Master F.G.; Master
D. Smith; Master F.G.; 1st Officer
R. Keene; Master F.G. (X); 2nd Officer
J.N. Christie; Radio Certificate; W/O
L.E. Clarke; Supply Officer
D. Marr; Engineer First Class Combined, Chief Engineer
W.G. Delany; Engineer 2nd Class Motor; Senior Engineer
L. Pride; Engineer 2nd Class Motor; First Engineer
G. Kyle; Engineer 2nd Class Motor; 2nd Engineer
L.G. Burton; 3rd Engineer

CSS WM.J. STEWART
J.P. Scanlan; Master F.G.; Master
J.G. Marston; Master F.G.; First Officer
C. Barboza; Mate F.G.; Second Officer
S. Palmer; Supply Officer
J.D. Henderson; Engineer 2nd Class Steam; Chief Engineer
R.B. Gibson; Engineer 3rd Class Steam; Senior Engineer
G. Loopeker; Engineer 4th Class Steam; Second Engineer
A. Conway; Engineer 4th Class combined; Third Engineer

CSS VECTOR
C.E. Macaulay; Master H.T.; Master
J. Grocutt; Master H.T.; First Officer
R.J. Easson; Master F.G.; Second Officer
G.W. Clouston; Engineer Third Class Motor; Chief Engineer
T.H. Storer; Engineer Third Class Motor; First Engineer
R. Pearson; Engineer Fourth Class Motor; Second Engineer

CSS RICHARDSON
C.M. McIntyre; Master 350 T.; Master
J.N. Henderson; Engineer Fourth Class Motor; Chief Engineer

C.F.A.V. LAYMORE
M. Dyer; Master
T. Taylor; Chief Engineer

M.V. RADIUM EXPRESS (Charter)
H. Bennett; Master
R. Green; Chief Engineer

PISCES IV (Submersible)
LCDR D. Harrison; Chief Pilot;(Seconded from DND)
CPTN P.S. Legallais; Pilot;(Seconded from DND)

DEPOT SUPERVISOR
V.L.E. Dale-Johnson; Master 350 T.

MARINE SCIENCES DIRECTORATE
PACIFIC REGION

ANNUAL REPORT – 1973

ENVIRONMENT CANADA
Fisheries and Marine Service
Marine Sciences Directorate
Pacific Region
1230 Government St.
Victoria, B.C.

MARINE SCIENCES DIRECTORATE

PACIFIC REGION

ANNUAL REPORT 1973

Hangar and temporary office accommodation
at the Patricia Bay site

Victoria, March 1974

Computer plot of CSS Parizeau's voyage to the western Arctic, summer 1973.

INTRODUCTION

During 1973 personnel of the Marine Sciences Directorate, Pacific Region, continued to strain to meet constantly increasing demands from many quarters. The judicious apportioning of our limited resources among efforts in Pacific coastal waters, in the Arctic and in the deep ocean; between the need for short-term programs to apply our expertise to immediate problems and the long-term programs necessary to maintain and extend this expertise, continues to be among our major preoccupations.

The efforts of the Field Hydrography Section must be divided among needs to complete the charting to modern standards of Pacific coastal waters, of performing necessary revisory charting of important areas subject to change both by engineering activity and from natural causes, of the special needs of the continuously growing recreational boating community, of the increasing demand for resource charting, and of the rapidly growing importance of the as yet ill-charted Canadian Arctic.

Progress was made on all of these fronts. For the first time on the west coast fully interdisciplinary resource charting was carried out. A special small craft chart, using a format designed in the region, was produced. The demand for this chart has been so great that it is clear we have responded to a hither-to unmet need, the full extent of which is probably not yet realized.

The continuously developing link and coordination of programs between the Tidal and Current Section of Hydrography and various sections of the Ocean Physics Division reinforces the wisdom of the unique Canadian organizational link between hydrography and oceanography. In addition to this internal cooperation, joint programs have been carried out with the University of British Columbia, the University of Washington and agencies of the United States National Oceanic and Atmospheric Administration. These cooperative efforts substantially increase the effectiveness of each of the participating organizations.

Although the Ocean Physics Division still has personnel on the UBC campus and one man in West Vancouver, and the Frozen Sea Research Group remains in its own quarters in Esquimalt, most of the division has now been gathered at Patricia Bay. This consolidation is already paying dividends in improved interaction.

Perhaps more than any other division, Ocean Physics is faced with very serious problems in appropriately apportioning its efforts among many needs: in coastal waters, in the Arctic, offshore; for long-term studies, for studies aimed at environmental impact statements, to meet requests generated by Fisheries biologists and those concerned with water quality. Limited resources have permitted carrying out time series or baseline studies only when they could be associated with situations of opportunity, such as the existence of a Canadian ship on ocean weather station P and of manned lighthouses around our coast. Most of our effort has had to be confined to near shore work, and even the Offshore Oceanography section has applied a substantial portion of its effort in near shore waters. Nevertheless, we have still been unable to mount any oceanographic study at all of B.C. coastal waters north of Vancouver Island. This situation cannot continue forever.

In the immediate future, however, the biggest increase in effort is likely to be in the Canadian Arctic. 1973 saw a significant increase in attention to this area, in particular in the organization of the forthcoming intensive study of the Beaufort Sea in connection with proposed exploratory drilling for oil. The accumulated experience of the Frozen Sea Research Group in the Arctic is proving to be a valuable asset in dealing with an increasing number of ad hoc problems in the Arctic Archipelago.

More than other divisions, the Ocean Chemistry Division has been able to focus its attention on oceanic and in particular baseline studies. It has been developing analysis tools, and some of these are now ready to be used, and are among the best in the world. The northeast Pacific contains water at least as suitable for baseline study as any other in the northern hemisphere, in that it is perhaps most nearly like the ocean was before man intervened. This effort has international as well as national implications.

The transition of Marine Sciences, Pacific from a strictly hydrographic - and within hydrography almost strictly charting and tidal - organization to one dealing with a broad spectrum of the physical sciences of the ocean has now been effected. Only just in time! The demands of the broad spectrum of marine sciences capability are increasing at an almost overwhelming rate.

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

A highlight of the year was the publication of the first British Columbia Small Craft Chart (3310) and the complementary Small Craft Guide, Volume 1. These publications were extremely well received with over 7,000 copies of Chart 3310 sold in less than six months.

Another first was the compilation, drafting and printing of a new tidal current atlas of Vancouver, which was produced completely from the regional office. The four-colour printing was done locally, on contract, with excellent results.

The Twelfth Annual Canadian Hydrographic Conference was held in Victoria in March, co-sponsored by the Canadian Hydrographers Association and the Pacific Region CHS. This conference was attended by over 160 delegates from government and industry, with representatives from the UK, USSR and USA.

Detailed activities of the Division are outlined in the following pages.

Hydrographers look for "a copper bolt set in the bare summit of Safety Mountain, Calvert Island," during a calibration exercise for Parizeau's summer program, in April, 1973

FIELD HYDROGRAPHY SECTION

R. Wills - Regional Field Superintendent

I.J. Campbell
E.B. Clarke
G.H. Eaton
N.S. Fujino
K. Highton
R.C. Hlina
L.P. Landry (from HQ)
J.B. Larkin
P.O. Lee
B.M. Lusk
C.G. McIntosh
A.R. Mortimer (at Central Region)
A.D. O'Connor
R.A. Pierce
A.R. Raymond
G.E. Richardson
G.W. Rogers
R.W. Sandilands
C.R. Tamasi
J.A. Vosburgh
P.Y. Yee

This section is responsible for all hydrographic field operations in the Region and includes Sailing Directions and the Hydrographic Development group.

CSS PARIZEAU carried out two main projects in 1973. The first was a natural resources charting survey from April 25 to June 8 with Mr. R.W. Sandilands as Hydrographer-in-Charge. The survey was conducted in conjunction with the Department of Energy, Mines and Resources for the purpose of collecting gravity, magnetic and seismic data as well as bathymetric information in Queen Charlotte Sound out beyond the continental slope.

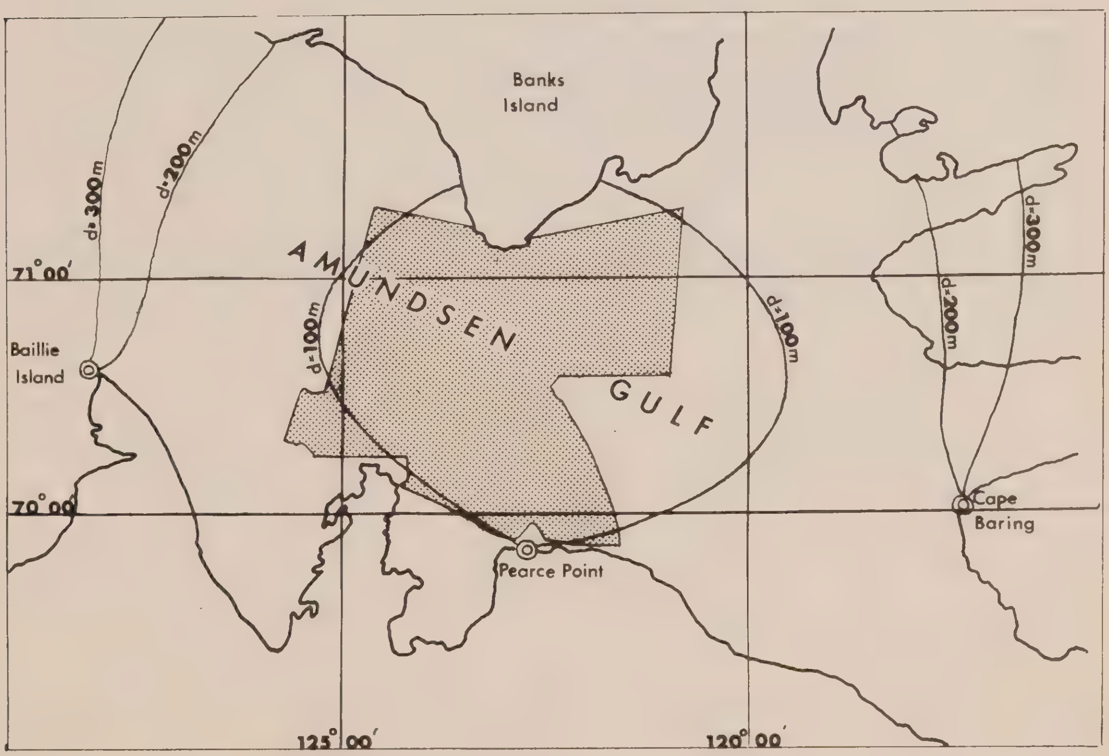
This was the first time a complete multi-disciplinary survey of this nature had been carried out in the Pacific Region. All agencies reported that a high percentage of usable data was obtained. Altogether 5,352 nm of magnetic, 5,045 nm of gravity and 1,745 nm of seismic data were recorded in addition to 5,472 nm of bathymetric soundings.

The second project, lasting from 4 July to 28 September, was the Western Arctic Survey with Mr. E.B. Clarke as Hydrographer-in-Charge. This was also a natural resources charting survey similar to that conducted in Queen Charlotte Sound but with greater emphasis on bathymetry and hydrography for navigational purposes. The main area of operations was in the western half of Amundsen Gulf between Banks Island and Cape Parry. A large amount of data was also collected on passage to and from the Arctic and a small reconnaissance survey was done of the approaches and entrance to Summers Harbour, Booth Island.

Heavy concentrations of ice were experienced off Cape Barrow during passage to the survey area, which caused some ship hull damage. Throughout the cruise, particularly in August, ice was a major problem blocking efforts to work on the most western field sheets, but weather conditions in general were exceptionally good.

The magnetometer and the gravimeter operated successfully throughout the season with only occasional minor breakdowns. There were two major equipment failures, the PDP 8/e computer and the satellite navigation receiver.

A total of 15,154 nm of soundings were obtained and preliminary reports indicated that good magnetic, gravity and seismic data were collected, 9,738 nm magnetic (5347 track), 9,807 nm gravity (5347 nm track), and 226 nm seismic. Bottom samples and sound velocity readings were taken throughout the main survey area and cores were obtained at eleven stations. Fish trawls were run for one hour periods on selected lines, usually in conjunction with bottom sampling operations.



Western Arctic survey area, summer 1973.

CSS WM.J.STEWART under the direction of Mr. C.G. McIntosh was engaged in conventional hydrographic surveys on the British Columbia coast from 16 April to 12 October. The main areas of operation were Howe Sound, the Strait of Georgia, Malaspina Strait including Powell River and Westview and Arthur Passage in the approaches to the Skeena River. A total of 3,673 nm of launch soundings were recorded on these projects.

A complete re-survey of Howe Sound was conducted with special emphasis on Shoal Channel and the approaches to and port of Squamish. Of particular interest was the successful use of infrared and colour photographs to define the low water line. The Howe Sound project was hampered by the large number of log booming grounds in the area. In many instances these extended from shore into forty or fifty fathoms of water and caused a great deal of difficulty with the continuity of inshore soundings. To overcome this problem a hand transportable echo sounder was devised, using an Edo digital sounder and light transducer from one of the launches. Though time-consuming, this method worked very well and enabled spot soundings to be obtained down to thirty fathoms.

The Strait of Georgia project completed the modern survey of the Strait with the exception of the central part of Malaspina Strait. A large scale survey of Powell River and Westview was completed. Motorola and Trisponder positioning systems were used on the surveys and worked well throughout.

The Arthur Passage project, which was carried out towards the end of the season, was hampered by weather ranging from bad to atrocious, with visibility greatly reduced by heavy rain and fog. In spite of this only one of twenty-eight days was completely wasted due to weather.

The Haro Strait shore party consisted of Mr. J.B. Larkin, two assistant hydrographers, a coxswain and a seaman. Its main items of equipment were the twenty-foot launch TERN, a seventeen-foot Boston whaler, a small office trailer and a Motorola RPS.

The projects were (a) the completion of shoal examinations and shoreline checking in Esquimalt Harbour and approaches, commenced in 1972, and (b) the completion of the Haro Strait survey which was started in 1970.

The Esquimalt Harbour project started on 9 April and continued periodically throughout the season for a total of sixty-seven operational days.

In the course of this project 113 nm of soundings were recorded and forty-three shoals were examined. Included was a large scale survey, 1:4,000, of Constance Cove.

Transponder was positioned on Mount Sarah, Swindle Island, in order to calibrate Parizeau's Hi-Fix positioning system used in the 1973 resource charting program

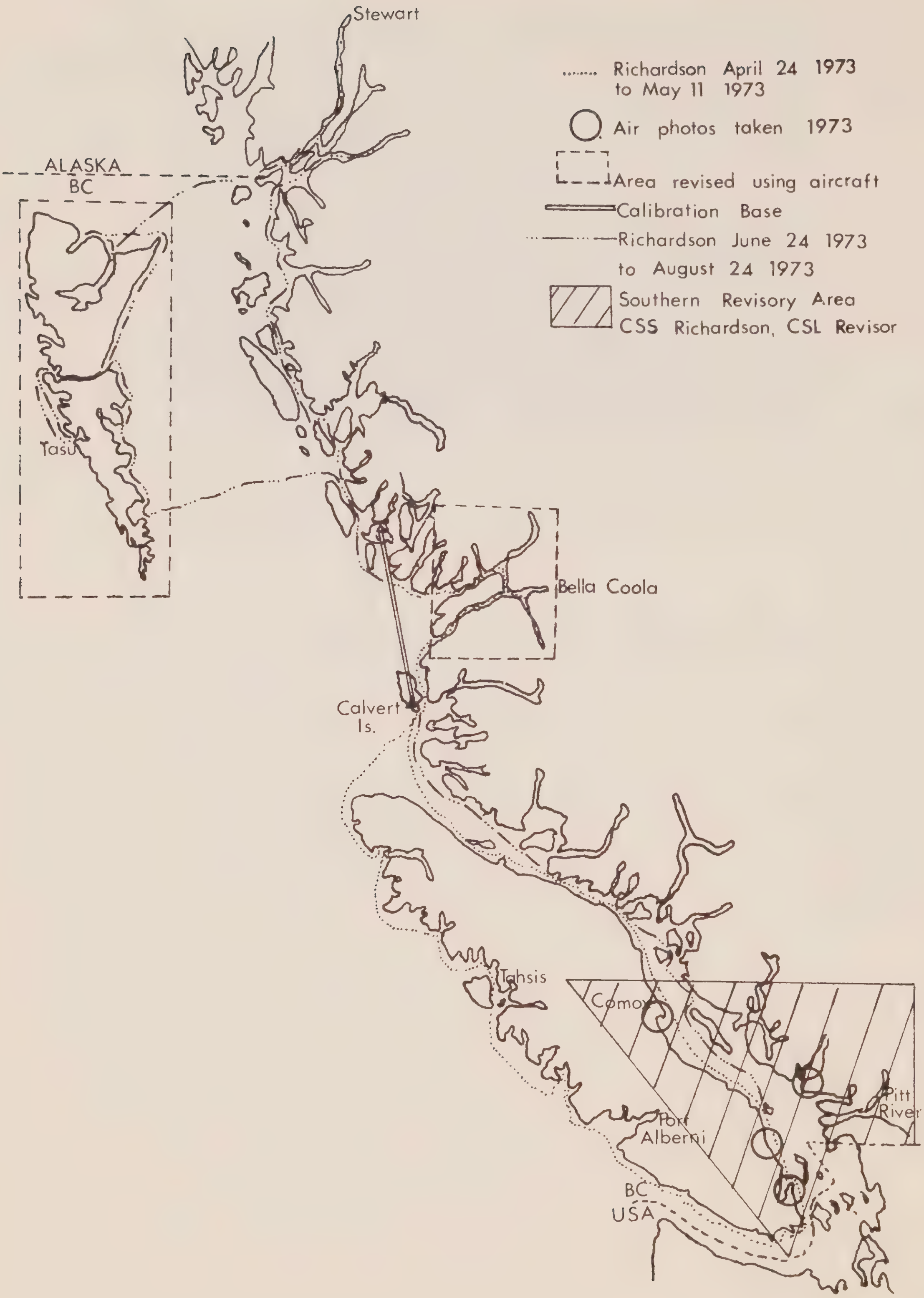
The Haro Strait project got under way on 28 May and continued for 118 operational days. This project produced 570 nm of soundings in an area of forty-two square nm. The two projects completed three field sheets and three wharf plans.

Of interest on the Haro Strait survey was the use of a shoreline and low water plot, including shallow water bathymetry, prepared by Airphoto Analysis Associates. Although not without discrepancies and omissions, this plot proved of great assistance to the hydrographers in the field. It is part of continuing research in the Aerial Hydrography Project.

In Plumper Bay, Esquimalt Harbour, we were asked to evaluate a log debris removal project. A sweep was made with side scan sonar and the records proved to be invaluable, as it was difficult to make an intelligent judgement on the basis of a normal echogram trace alone.

Revisory surveys, with Mr. A.D. O'Connor in charge, had a successful season of 202 days, employing at different times CSS RICHARDSON, CSL REVISOR and CSL CRANE.

The first project was a revisory survey of Shuswap Lake, about 200 miles northeast of Vancouver. The launch CRANE was used and the project was completed in seven operational days, of which two were actual field work. As a result of this work Chart 3501 was revised.



British Columbia coastline survey program, 1973.

The second project, for which CSS RICHARDSON was used, lasted 156 operational days of which 98.5 were occupied in actual field work. The first task of this project was to assist PARIZEAU in the calibration of her Hi-Fix system for the Queen Charlotte Sound operation; the remaining time was devoted to the northern and southern areas of the British Columbia coast, including the Queen Charlotte Islands.

This was the first year that a revisory survey party had been assigned to northern areas; in the past, revisions on the northern B.C. coast were carried out on an opportunity basis by parties engaged in normal hydrographic surveys. A large number of changes were noted. Visits were made by RICHARDSON to the location of each reported change and revisions were made of the charts traversed en route; aircraft were chartered to fly over charted areas where little change was expected.

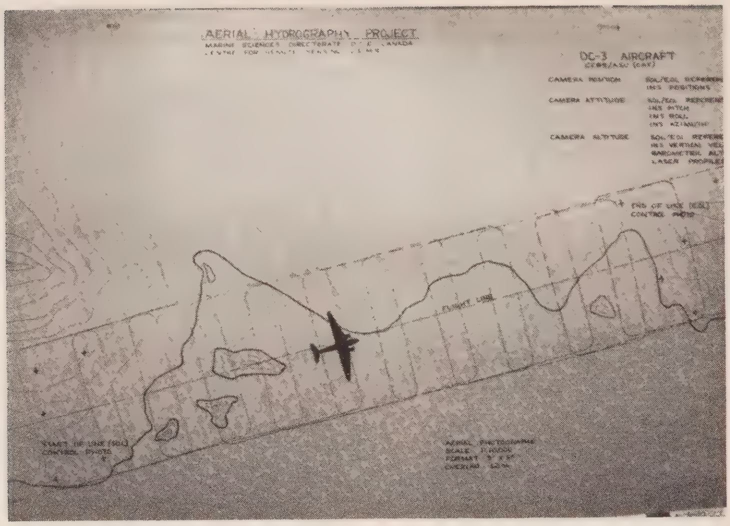
Another project involved the large scale survey of a portion of Patricia Bay, the future home of the Institute of Ocean Sciences. Then revisions were continued in the Strait of Georgia and the survey team proceeded to Pitt River, northeast of New Westminster. The work there involved the recovery and photo-identification of the Department of Public Works' control, the coast-lining of the river and the collection of supplemental information. This involved twenty-two days of field work.

Other miscellaneous projects were undertaken, including a large scale survey at Fisherman Cove.

As a result of the season's work the entire 3800 series of charts, covering the Queen Charlotte Islands, was revised together with the following charts:

3711	3736	3772
3722	3739	3781
3729	3740	3790
3730	3743	3793
3733	3745	3794

Several aircraft were used successfully. The Beaver aircraft was particularly valuable as its construction enabled a K-20 camera to be used through the floor of the cabin for the vertical photography of low water shorelines. The use of a Cessna 185 in the Bella Coola area enabled chart checks to be carried out in four hours that would have taken three days in RICHARDSON; similarly, a Cessna 180 aircraft was used to cover a territory in the Queen Charlotte Islands in eight hours that would have taken RICHARDSON ten days (weather permitting).



Coastal photography for aerial hydrography will utilize an Inertial Navigation Unit to determine the photo-orientation parameters. These parameters will be updated at the beginning and end of each flight line by ground control points

Mackenzie River survey was conducted by Mr. G.E. Richardson and his party using the Northern Transportation Co. chartered vessel RADIUM EXPRESS as a base of operations. The number of days spent in the area of operations was 99.5 of which twelve were lost to weather, one to equipment failure and only 3.5 to weekends and holidays.

About 4.5 days were consumed in locating a sunken DPW dredge at Norman Wells by using side scan sonar. Another day was spent using the same equipment to locate a sunken tank at Fort Norman. After these projects sounding surveys of Charts 6417, 6418, 6423, 6425, 6426 and 6438 were completed and revisory surveys of East Channel, Kugmallit Bay and Tuktoyaktuk were carried out. Reconnaissance surveys were also carried out in Husky, Phillips and Enoch Channels. Sounding surveys are now continuous from Old Fort Point (Mile 480) to Point Separation (Mile 915) and reconnaissance soundings have been done in most of the delta channels.

A Mini-Ranger positioning system gave excellent service and suffered no down time throughout the season. This was a most productive and trouble-free field survey, attributable mainly to good equipment preparation and the planning which incorporated the lessons learned from the experience of the previous two seasons.

HYDROGRAPHIC DEVELOPMENT SECTION

N.M. Anderson - Head

* F.S. Coldham
D.C. Gillett (university summer student)

* R.D. Popejoy
* M.V. Woods

* Rotational Hydrographic staff.

In the course of the year the group evaluated two range-range positioning systems, Mini-Ranger and Trisponder. The Mini-Ranger system's stability, precision and repeatability were observed from baselines ashore at various ranges from two to 21.5 km and up to twelve km afloat. A report titled "An Evaluation of the Mini-Ranger Positioning System" has been published.

The Trisponder positioning system, which had been evaluated previously, was re-evaluated after the group was notified by the manufacturer that a completely new transponder had been developed. A launch failure limited the sea trials but all land-based tests were completed and the results have been published in "An Evaluation of the Trisponder 202A with Model 210 Transponders."

Because systematic errors (delays between "receive" and "transmit" in the transponders) seem to be inherent in these positioning systems, seven base lines ranging from two to 21.5 km in length were established and will be used for the future evaluation of short range systems; for the evaluation of these systems at their maximum ranges additional test ranges will be needed.

The Wild RC-10 camera used for aerial hydrography will have the Inertial Navigation Unit (INU) mounted directly above it in order to ensure a fixed attitude and azimuth relationship between the camera plane and the INU reference plane

Several useful computer programs were written by a university student, Mr. D.C. Gillett, for the compilation and analysis of survey statistics. These include:

- Daily plots of weather data
- Final field report statistics
- Chart priorities
- Critical path, Aerial Hydrography Project.

Work on the Aerial Hydrography Project is proceeding and the Canada Centre for Remote Sensing has agreed to develop an airborne hydrographic system (AHS). An engineer and a technician from MSD Pacific are assigned to CCRS, Ottawa, for the duration of the project. The functional parts of the AHS include the inertial navigation system (INS), the airborne terrain profiler (ATP), the camera (RC-10) and the airborne data acquisition system (ADAS). The central part of the processing facility is the analytical plotter (APC).

SAILING DIRECTIONS SECTION

T. Jones - Head

J.W. Chivas

The group completed a revision of the British Columbia Sailing Directions, Volume 1 which involved the incorporation of 586 alterations and additions. During this revision the opportunity was taken to include the coordinates for all the place-names in the index.

The British Columbia Sailing Directions, Volume 2, has been re-written to conform with the new format for all sailing directions. This is in manuscript form and will be published in 1974.

A revision of the Small Craft Guide, Volume 1 has also been completed and involved a total of 231 alterations and additions. This too will be published in 1974.

In August, Mr. J.W. Chivas undertook a revisory survey of the area covered by the Kootenay Lake and River Sailing Directions and collected a considerable amount of information for the revision of this publication.

The group also undertook the compilation of a first draft of "Instructions for the Revisers of Canadian Sailing Directions" which will eventually become the official manual for the guidance of Sailing Directions' personnel.

TIDAL AND CURRENT SECTION

S.O. Wigen - Regional Tidal Superintendent

The Tidal and Current section conducts field programs in the Pacific and Western Arctic Regions, and in the Mackenzie-Athabasca Waterway. Its activities for 1973 are reported under the four units of the section.

Hydraulic Research

A.B. Ages
K.S. Lee (CELL)
A.L. Woollard

Improved tidal predictions along the lower Fraser River have been produced by the application of the previously developed numerical model. Study of the salinity wedge in the Fraser Delta is continuing, and field measurements have been made with a CSTD instrument. Work has started on a two-dimensional numerical model of Burrard Inlet, to improve the interpretation of circulation in Vancouver Harbour.

Swans investigate pink plastic oil spill marker designed by Tidal and Current section to drift at leading edge of oil spill. Signals from transmitter in dome can be picked up by aircraft up to four miles away to track oil at night or in fog.

As part of its work in Canada's Oil Spill Task Force, members of the unit participated in operations resulting from two main mishaps, the grounding of the IRISH STARDUST near Alert Bay in February, and the collision involving the ERAWAN in Burrard Inlet in September. In each case oil movements were tracked, and oil coming ashore was located and quantities estimated.

Current Surveys

W.S. Huggett
J.F. Bath
A.N. Douglas (Computing Services)
W.J. Harris
F.V. Hermiston
T. McNie

A major current survey employing forty-two current meters and monitoring the flow through both Johnstone Strait and Juan de Fuca Strait simultaneously was carried out from February to June. This is the largest survey of its type undertaken to date. One of the primary purposes was to measure the flow through each cross section with sufficient accuracy to define for the first time the net circulation around Vancouver Island.

As part of the eighteen-month Beaufort Sea Project an observational program has been planned to measure tides and currents from close inshore out to the edge of the continental shelf and to relate meteorological effects to storm surges. As the first phase of the field program tide gauges and current meters were moored offshore through the ice pack in October, by a helicopter party. These instruments will be recovered by ship in July 1974. The data from these instruments will be used in calibrating a numerical model of the Beaufort Sea, now being developed.

A new current atlas of Vancouver Harbour has been produced as an aid to navigation.

Tidal Survey

R.E. Brown
W.J. Rapatz
J.D. Scott (CELL)
F.E. Stephenson

Several tide gauges supporting the current survey mentioned earlier were maintained on the Pacific Coast throughout the year. Gauges at Port Renfrew and Kelsey Bay were upgraded to give more accurate information for the numerical model of Juan de Fuca and Georgia Straits.

A new tidal station employing an improved bubbler type gauge has been brought into service at Langara Point on the north-west corner of the Queen Charlotte Islands. This station transmits instantaneous water levels to a monitoring station at Prince Rupert airport, and through this station is now joined to the Pacific Tsunami Warning Network on an emergency basis. It will provide warning more than an hour earlier than was previously possible in the event of a tsunami from an earthquake in the North Pacific.

In the Arctic, five tide gauge stations were established on a seasonal basis around the southern perimeter of Amundsen Gulf, to expand and update tidal information, and to support the hydrographic charting program carried out by CSS PARIZEAU. Gauging stations were established at Cape Bathurst and Herschel Island, to record through the winter and spring months. Some of the gauges in the above were of a new type employing sophisticated electronic circuitry and recording on magnetic tape. Much testing and some improvements had to be carried out before the gauges were used in the field.

In the Mackenzie River, four water level recording stations were established during the ice-free period and vertical control for hydrographic charting was improved and updated between Fort Good Hope and the Delta.

The tidal unit spends much time each year providing information to the public, and to engineering firms and port authorities regarding water levels and datum planes on the Pacific Coast and in the Western Arctic.

Data Processing

S. Ames M. Lee
D.E. Hilder

This unit processed the records from all temporary stations established by the Tidal unit and by Hydrographic field parties. The records were digitized. Hourly heights, high and low waters, and mean and extreme levels were extracted and forwarded to Ottawa for analysis and inclusion in "Water Levels Volume 3". Procedures to facilitate digitizing and to process strip charts and magnetic tapes were improved.

CHART CONSTRUCTION SECTION

F.R. Smithers - Regional Chart Superintendent

This section is responsible for the compilation of new charts from new surveys, the revision of published charts for new editions and the hand correction and distribution of all nautical charts and publications to 180 authorized chart dealers. It is also responsible for graphic arts for exhibits, lecture material and illustrations for Directorate publications as well as photographic and printing services for the region.

Chart Compilation

R. Bell
R. Banyard
T.C. Plume
M.S. Taylor
L.G. Thompson
B.M. Watt
V.N. Young

The compilation unit completed drafting the following first editions in 1973:

3701 - Prince Rupert Harbour
3804 - Masset Harbour
3980 - Plans in the vicinity of Chatham Sound
3532 - Baynes Sound and approaches
3989 - Brown Passage
3991 - Hudson Bay Passage

The unit is also responsible for the construction of Directorate displays, graphic arts, photography and printing requirements in the region.

Chart Correction

K.M. Bennett
D.J. Clark
E.M. Coulter
B. Grau (CELL)
M.M. Patton
J. Pielak (CELL)
R. Wakefield (CELL)

This unit hand-corrected 267,500 charts which required 2,118,400 corrections before they could be distributed to authorized dealers for sale to the public.

Displays and Exhibits

The Chart Construction section set up and staffed a nautical chart display at the Vancouver International Boat and Sport Show for a two-week period in February. The theme was the new small-boat chart 3310, which comprises four accordian-type foldout sheets covering the waterways from Victoria to Nanaimo. There were 700 copies sold at $5.00 a set at the show.

Again this year the section participated in the shopping mall displays that were held at the following locations: Lougheed three weeks, Richmond two weeks, Brentwood six weeks, Nanaimo two weeks, South Park Royal four weeks, Pacific Centre three weeks and the Victoria Jaycee Fair one week. The Strait of Georgia model is one of the main attractions at these shows and has been placed in the Student Union building at UBC until January when it is expected that the shopping mall displays will re-commence.

In October Mr. F.R. Smithers attended the National Power Boat Convention at St. John, N.B. as a government representative for the MAREP program. This is a marine reporting system where all squadron members participate by reporting any discrepancies they find on Canadian charts while cruising. Each year an award is given for the most useful reports and the Vancouver Island group is to be congratulated for winning this award for the second consecutive year.

Marine Sciences exhibit designed and manned
by Chart Construction section for shopping mall displays

Chart Distribution

J.H. Coldwell
R. Johnson (CELL)
C.J. Nast

This unit processed and distributed 165,000 nautical charts and 40,000 related publications. The facilities of eighty-four authorized chart dealers were inspected and after these inspections eleven dealerships were cancelled. Twenty-two new dealers were authorized to sell charts and publications.

Chart Revision and Notices to Mariners

P.C. Browning
D.G. Dobson
K. Holman
A.G. Lyon
A. Philp

The revision unit has completed drafting the changes to twelve new editions of nautical charts as a result of new hydrographic information. Major corrections were drawn and published on forty patches. There were fifty-one Notices to Mariners promulgated from this office for publication. Seventy-two MAREP reports were received from the Power Boat Squadrons and acted upon.

SURVEY ELECTRONICS SECTION

J.V. Watt - Head
(with CCRS)

G.L. Cooke
* T.A. Curran
L.W. Dorosh
T. Dyas
D. Gregson (with CCRS)
E.W. Hinds
* A. Koppel (with FSRG)
C.F. Ryan
W.R. Taylor

* Joined during 1973.

As in the past, the primary task of the Electronics group is to provide maintenance, installation and repair services as dictated by requirements of Hydrography and Ship Division. The group's secondary task, and one which has increased notably in the past year, is the provision of engineering and technical support to other sections within the region, e.g. Ocean Chemistry, Tidal and Current, Coastal Zone Oceanography.

Equipment serviced included sonar and echo sounder systems, precise positioning systems, data acquisition systems, numerous tellurometers, ships' radar and navigational aids, HF and VHF communications, computers and computer peripherals. In addition to two Motorola range positioning systems and one Motorola Mini-Ranger system already in service, delivery has just been taken of a second Mini-Ranger system (MRS).

During the winter of 1972/73 the first MRS was returned to Motorola for overhaul; however in 1973 the electronics lab acquired the necessary equipment to carry out its own overhaul of this type system.

RPS was used on PARIZEAU at the beginning of May to calibrate the Hi-Fix chain in Queen Charlotte Sound. The multiplexer was tied into the Decca 629 radar waveguide and that transmitter assumed the master function. Using this configuration PARIZEAU was able to work to the maximum specified range of RPS. However, this was with one transponder only. The second one refused to operate beyond close range. Outside of that and a breakdown in the three-pulse encoder of the multiplexer transmitter of the second RPS no significant problems arose and operation of both systems was generally trouble-free.

PARIZEAU's Arctic expedition was plagued for a time with trouble in the PDP 8/e, an intermittent in the Kennedy 1600 tape recorder, a problem on the 408 sounder digitizer.

In communications, 1973 saw the beginning of the conversion from AM to SSB on Pacific Region's vessels with installation of a 12-channel SSB transceiver on RICHARDSON to replace the 10-channel AM equipment. Five more AM radiotelephones are to be replaced by SSB equipment now on order and expected to be delivered by the end of the year. During 1973 VHF transceivers were installed for the first time on RICHARDSON, REVISOR and GULF OF GEORGIA #192, a support barge for PISCES IV.

Another two of the few remaining Kelvin Hughes MS26B echo sounders were retired at the end of the '73 field season. These are to be replaced by Atlas dual frequency sounders operating at frequencies of 33 kHz and 100 kHz. Another Atlas of the same type and frequency is to be installed in WM.J.STEWART early in 1974.

For Ocean Chemistry, extensive modifications to an LDC Mercury Monitor were performed to increase sensitivity and reduce noise. Range scaling was performed on the PCO2 analyzer to make the output compatible with a Honeywell recorder input. Two temperature monitors supplied by Interocean Systems were calibrated and interfaced to Heathkit chart recorders.

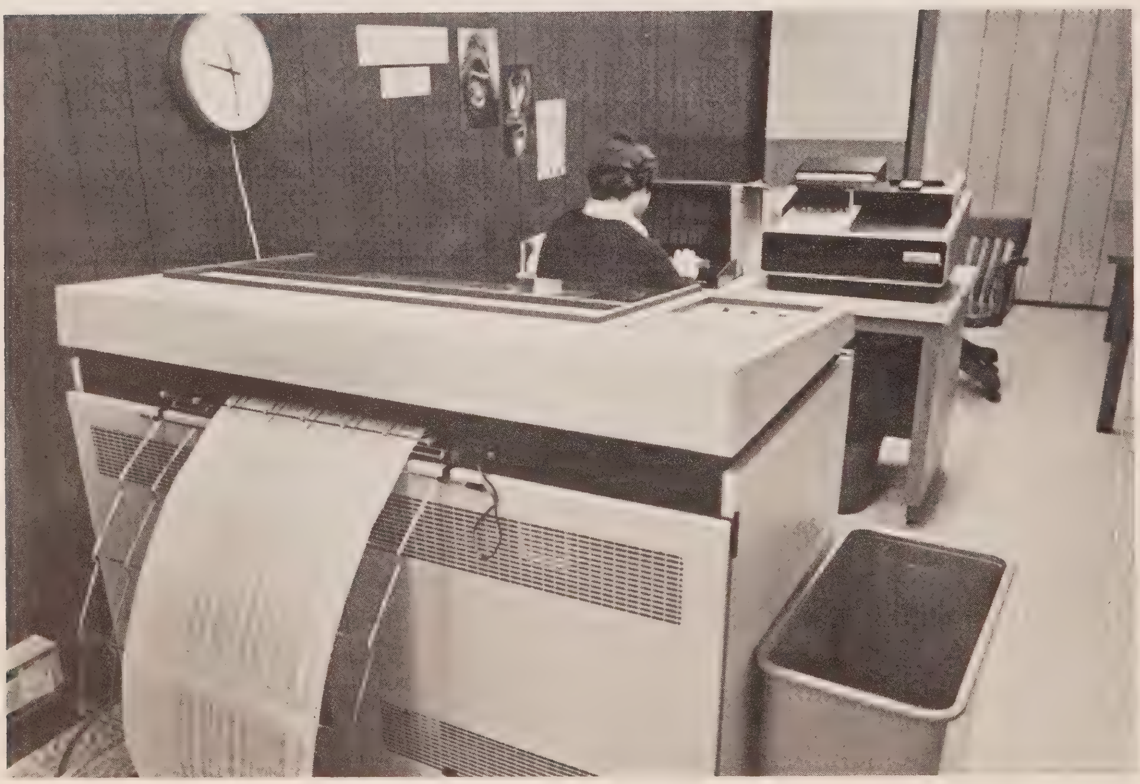
For Coastal Zone Oceanography the section designed, built and field-tested an electronic bathythermograph (EBT) which was used intensively in Babine Lake. Expectations for a new multichannel data acquisition system have not yet materialized and work is continuing. A pulse shaping unit was developed to improve readability of poorly recorded Aanderaa data tapes.

THE LIBRARY

L.S. Thomson - Librarian

In 1973 one full-time professional librarian and one library assistant were appointed. The collection increased to about 4,000 volumes, although journal subscriptions remained static at 125.

About one quarter of the holdings were moved to Patricia Bay shortly after the research groups moved there. The librarian remains at the downtown location where the main reference collection, catalogue and other materials are kept.



Computing Services' Comtern remote batch terminal at Patricia Bay is connected via telecommunication lines to a large scale computer at UBC

OCEAN ENGINEERING DIVISION

INSTITUTE OF OCEAN SCIENCES - PATRICIA BAY

N.A. Todd - Project Manager

Considerable progress has been made during 1973 in planning for the West Coast Institute. Some units of MSD, Pacific Region, have been located in temporary accommodation on the site.

Early in the year the department hired a firm of consultants, The Environmental Analysis Group (TEAG) to study and report on the functional needs of the new institute. This report was submitted at the end of March. Prior to its completion approval in principle for the construction of the institute had been received from the Treasury Board.

Progressing from the TEAG report, the Department of Public Works was approached and a brief defining in greater detail the type and size of facilities required was prepared. This was completed as the year closed and it is anticipated that the consultant architects will be appointed on a basic fee basis very early in the new year. The design of the marine facilities will be carried out by the Department of Public Works who will also supervise construction. Present planning calls for construction of both the marine and land facilities to start in fiscal 1974-75 with completion and occupancy in 1977.

Permission was obtained from the Department of National Defence to use one-half of one of the two hangars on the site. The old office space within the hangar was modernized, allowing the Coastal Zone Oceanography group which had been located in the Pacific Environment Institute in West Vancouver to move to the Island in August. Nine 40' x 10' modular offices were installed, five of them inside the hangar and four outside. These are being used by the Offshore Oceanography group and by Computing Services. Four more modular offices arrived late in December and will be occupied by Ocean Mixing and Remote Sensing.

It does not appear feasible to move any more of the existing units to Patricia Bay until the entire Region can come together in the new institute. The decision by the Department of Energy, Mines and Resources to locate sizeable groups of the Geological Survey of Canada and the Earth Physics Branch within the institute is very welcome and ensures that coordination and execution of joint programs will be easier and more effective than in the past.

COMPUTING SERVICES SECTION

K. Teng - Head

R.E. Johns
J.W. Butcher (with FSRG)
A.N. Douglas (with Tidal & Current)
C.G. Morgan (with Ocean Chemistry)
P.J. Richards (with Numerical Modelling)
D.B. Smith (with Offshore Oceanography)

1973 marked the first year of Computing Services as a section. The initial project was to study computing services requirements for MSD Pacific Region and to prepare a report with short-term and long-term objectives and a plan towards meeting three objectives. The report, entitled "Towards Better Computing" appeared in June, 1973.

The most pressing need was to provide adequate computer access for groups relocated to the Patricia Bay site. A COMTERM 1200-H intelligent remote batch terminal was installed, controlled by a PDP-11/10 minicomputer. Data communications with external large-scale computers is accomplished via 2000 bits/second dial-up telephone lines. We are currently using the UBC Computing Centre (IBM 370/168) and Computer Sciences Canada, Calgary (UNIVAC 1108). Other equipment installed at the Patricia Bay site includes an HP 2115 minicomputer (Offshore Oceanography) and a dial-up low-speed conversational terminal (B.C. Tel VUCOM) with non-impact printer.

The HP 2116 computer (Tidal and Current) in the Federal Building has been upgraded with the addition of a disk sub-system which features removable disk packs (2.5 million bytes capacity each), and the replacement of the old card reader.

Advice is provided to sections evaluating dedicated mini-computer and data acquisition systems. The Ocean Chemistry Division acquired a disk based PDP-11/10 for laboratory and shipboard applications.

OCEAN CHEMISTRY DIVISION

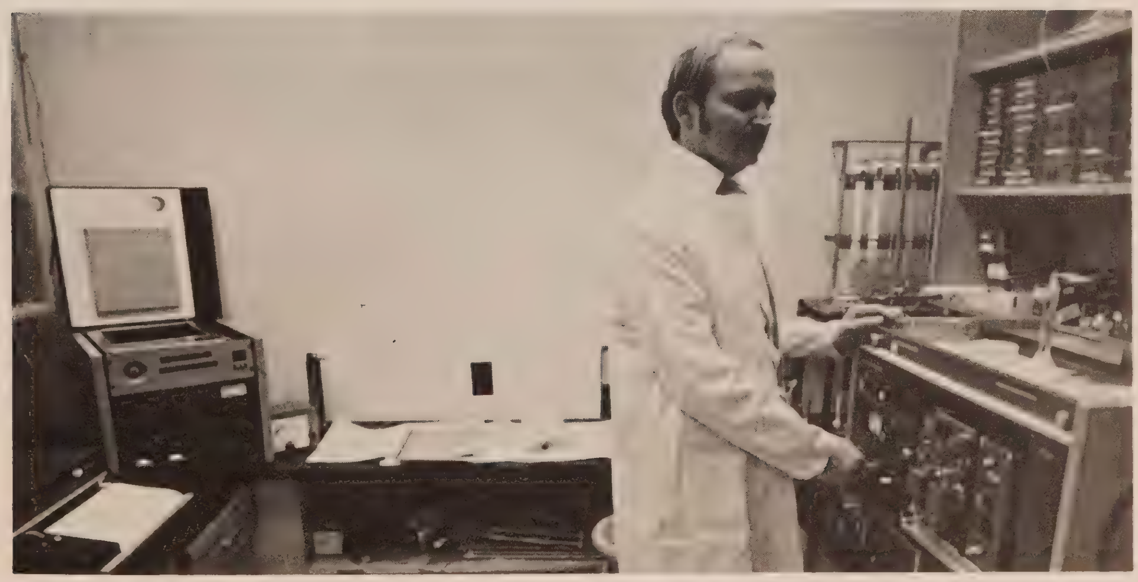
C.S. Wong - Chief of Division

MARINE HYDROCARBONS SECTION

W.J. Cretney
D.R. Green (visiting student, UBC)
K.W. Johnson
R.W. MacDonald (NRC Postdoctoral Fellow)

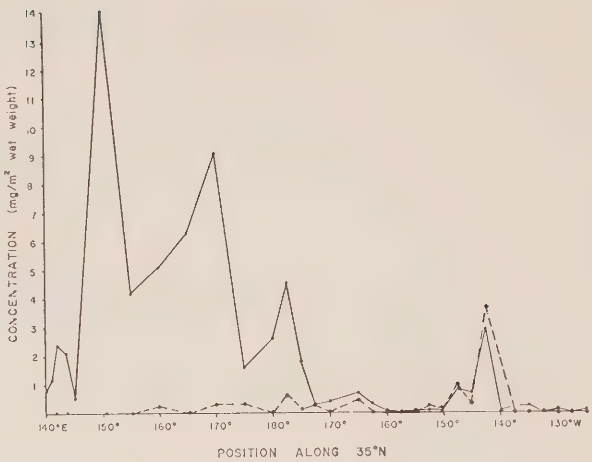
The behaviour of petroleum-based hydrocarbons in the marine environment is complicated by its interaction with another complex substance, sea water. Sub-lethal effects might be caused by very low levels of such hydrocarbons, the detection of which requires an analytical ability at the sub-microgram level and a contaminant-free working environment.

Much effort has been devoted to shore-based and shipboard facilities, with ability to determine total hydrocarbons at 1 μg/l to 1 ng/l. A spectrophotometric technique has been adopted to study line P, Saanich Inlet and Gorge sea water samples for polyaromatic hydrocarbons. A method for a more complete analysis of sea water using high-speed liquid chromatography has also been adopted.



A high speed liquid chromatograph, right, reduces analysis times from hours or days to seconds or minutes. A gas chromatograph, left, provides high sensitivity and separating power

The occurrence of tar balls in the Pacific Ocean and on beaches of Vancouver Island was investigated under the marine hydrocarbons program. A beach survey for oil residues in southern Vancouver Island was conducted by We Healdath Ltd. under contract and showed absence of tar lumps at the time of the survey. Regular Neuston net tows on line P also showed no tar lumps in the N.E. Pacific Ocean. A Pacific tar map is being prepared using samples from TRANSPAC-72 and Neuston net samples examined by D.R. Green at Scripps Institution of Oceanography. Analysis of tar balls from TRANSPAC-72 is being conducted using atomic absorption for iron content and gas chromatography for n-paraffins.



Distribution of tar (indicated by solid lines) and plastics (indicated by dashed lines) along 35°N in the Pacific Ocean.

A weathering study of stranded oil at Alert Bay was conducted on a selected beach area after the IRISH STARDUST grounding. To complement this, some artificial weathering experiments were carried out. Work is still in progress on the gas chromatographic analysis of degraded samples.

A gas chromatographic method is being set up to study the occurrence of low molecular weight hydrocarbons in sea water and the air-sea exchange of such volatile components.

MARINE CARBON BUDGET SECTION

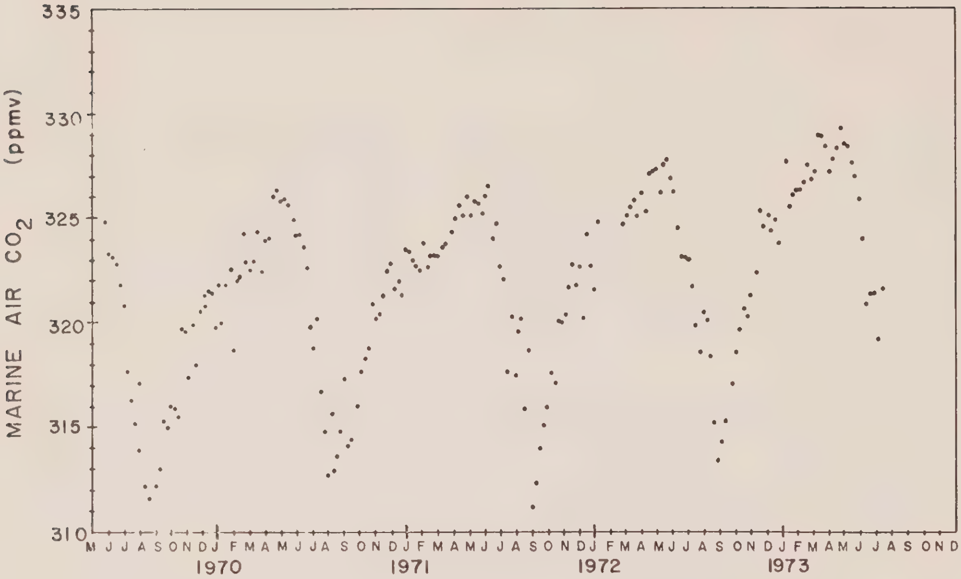
R.D. Bellegay
A.B. Cornford
C.M. Jackson

Concern regarding the possible climatic effects of CO_2 released into the atmosphere by burning of fossil carbon requires a close surveillance of the natural CO_2 system. The input of CO_2 from fossil fuel burning has been doubling every twenty years. However, the continuous exchange of CO_2 in the atmosphere-ocean system and to a lesser extent, the biosphere, has kept the atmospheric CO_2 increase at a slower rate than the input. The carbonate chemistry of the surface ocean is playing a vital part in the CO_2 equilibration process in this global atmosphere-ocean system.

Research effort has been focussed on long-term time-series studies of CO_2 exchange in the atmosphere-ocean system, in particular, at ocean weather station P (50°N, 145°W), which is the only fully marine CO_2 station in the world. Three important areas are being studied: (1) marine air CO_2 increase, (2) air-sea CO_2 exchange and carbonate chemistry in the surface sea water, and (3) radiocarbon study of CO_2 exchange rate.

Marine air CO_2 increase has been monitored for the fifth year in a DOE-Scripps Institution of Oceanography joint collection program at station P. The time series confirms a more rapid rate of increase in atmospheric CO_2 in recent years: about 0.9 ppmv/yr., 35% higher than the average change of 0.7 ppmv/yr. for 1959-68 at Mauna Loa, Hawaii. The seasonal amplitude appears to be latitude dependent, decreasing from north to south: 20 ppmv (Alaska, Scandinavia), 15 ppmv at 50°N (station P and 10 ppmv at 19°N (Mauna Loa).

The invasion and evasion of CO_2 in the surface mixed layer at station P are being investigated by time-series studies of pCO_2 in air and sea water, and of carbonate chemistry in the surface waters. Two fully automated measuring systems for shipboard work on marine air CO_2 and equilibrated pCO_2 in surface waters were installed on the weatherships QUADRA and VANCOUVER for seven-week cruises: 73-006, 73-008 and 73-009. The results, which should indicate the magnitude of the seasonal shift of oceanic pCO_2 difference, are being processed. The system on the QUADRA will be used in the GATE (GARP Atmospheric Tropical Experiment) program. The carbonate chemistry parameters have been monitored since 1971. The rather constant total alkalinity, 2.17 meq/kg (±0.4%), is expected since the oceanic uptake of CO_2 would not cause change in carbonate alkalinity by the chemical reaction $CO_2 + CO_3^{=} + H_2O + 2HCO_3^-$ over a short time period. However, over a time scale of centuries, the increasing acidity would shift the supersaturated state of the surface ocean water with respect to calcite to an undersaturated state, thus causing dissolution of solid calcium carbonate and hence an alkalinity change. It is important to see if the carbonate ion in the ocean, and hence the alkalinity, would shift over periods of twenty to forty years as a result of this oceanic uptake of increased atmospheric CO_2.



Time series measurements of marine-air CO_2 concentration at ocean weather station P show a rate of increase in atmospheric CO_2 of about 0.9 ppmv per year, higher than in previous years

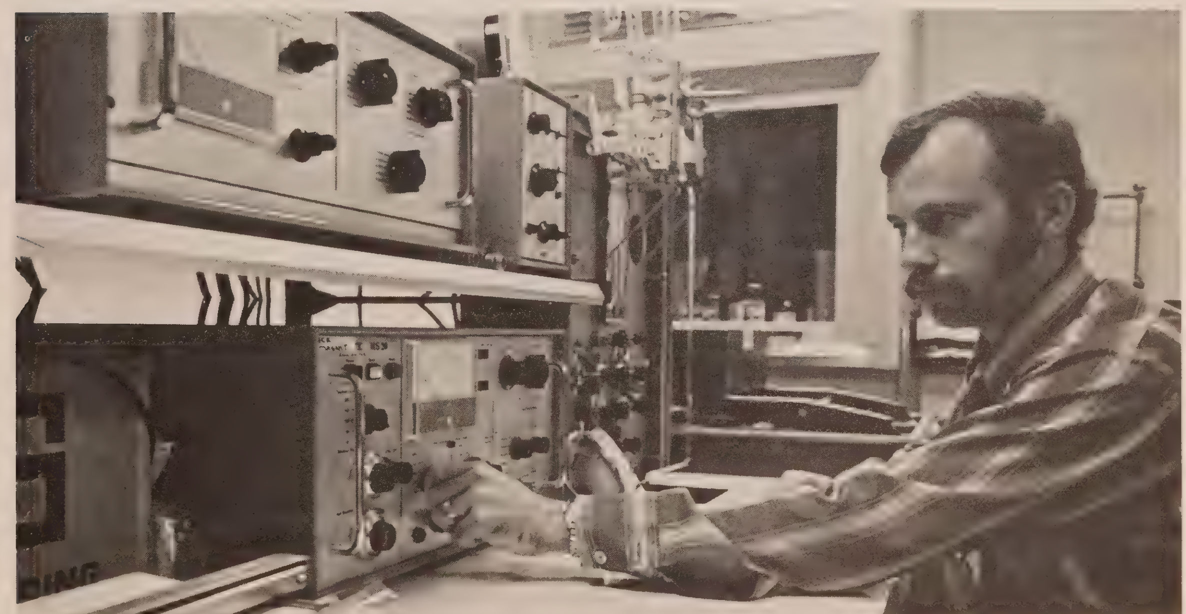
The radiocarbon laboratory at B.C. Research is in operation. Two counters, a smaller 0.4 liter OFHC copper counter and a second larger 1.25 liter OFHC Stuiver-type quartz-lined proportional counter, were fabricated and tested. Calibrations were carried out with five samples from a complete series of tree rings (678-1968 A.D.) obtained from the stump of a Douglas fir tree near Shawnigan Lake, V.I. (provided by Dr. M.L. Parker of the Canadian Forestry Service) and a sixth tree ring intercalibration sample GSC#22 (provided by Dr. J.A. Lowden at the Ottawa GSC Radiocarbon Laboratory). At present, an intercalibration with the radiocarbon laboratories at the University of Washington (Dr. Stuiver) and the University of Miami (Dr. Ostlünd) is being carried out using GEOSECS radiocarbon samples analyzed previously by both Stuiver and Ostlünd. An AEI MS20 isotope mass spectrometer was set up in the Ocean Chemistry premises at Harbour Road.

TRACE METALS SECTION

P. Berrang (visiting student, UVic)
D.J. Francis (NRC Postdoctoral Fellow)
W.J. Pannekoek
J. Piuze (NRC Postdoctoral Fellow)
C.S. Wong

The main objective of the trace metals program is to assess the natural and anthropogenic inputs of physiologically significant metals into the marine environment, with special reference to coastal and marine waters. As in the case of ultra-trace hydrocarbon analysis, trace metal analyses require dedicated clean laboratories to seal off airborne contaminants, in particular, lead aerosols. Much effort has been spent on setting up proper clean shore laboratories capable of at least 95% removal of 1-micron size airborne particles. A shipboard clean laboratory with similar capability has been designed and ordered.

A mercury method using cold vapour atomic absorption at 254nm Hg line has been developed for total and free mercury in sea water, and intercalibrations with Dr. Bothner, an originator of such a technique at the University of Washington, were carried out.



Ocean Chemistry's AEI MS20 mass spectrometer determines isotope ratios of several elements giving evidence of their origin

The important question of the pathways of lead in the marine environment is being investigated using atomic absorptiometric technique (flameless) and mass spectrometric method. A fast digital recording system to capture signals to four figures in 1 msec. was developed to optimize a flameless AA technique for lead, using a Jarrell-Ash 82-810 AA with an MTA-2 tantalum ribbon accessory.

Chemical speciation of trace metals in sea water will be investigated by Dr. Piuze, who arrived near the end of the year.

CHEMICAL MONITORING PROGRAM AT STATION P

R.D. Bellegay
C.M. Jackson
K.W. Johnson
F. McLaughlin (CELL)
P. Munro (CELL)
W.J. Pannekoek

Long-term trends of chemical parameters at ocean weather station P (50°N, 145°W) were monitored as a continuing effort of the division. The following observations, measurements or sample collections were made: (a) tar balls or other surface pollutants, collected by Neuston net tows from Victoria to station P, (b) weekly samples of atmospheric CO_2, surface alkalinity, total CO_2 and surface radiocarbon, (c) continuous infrared measurements of marine air CO_2 and pCO_2, starting in August on a quarter-yearly basis, (d) daily nutrients at surface waters of station P to provide information and long-term fluctuations in relation to circulation and marine food chain and (e) tritium samples.

BEAUFORT SEA, GATE, CEPEX

A substantial part of the resources was spent on cruise preparation for the Beaufort Sea project and the GATE program, both scheduled to take place in 1974. The work involves setting up chemical methods for baseline hydrocarbon study and construction of a shipboard clean laboratory for the Beaufort Sea program; and setting up the fully automated pCO_2, air CO_2 continuous measuring system for participation in the GATE program. Participation in the international Controlled Ecosystem Pollution Experiment (CEPEX) field studies in Saanich Inlet, B.C. was mainly in the planning and preparatory stage for (a) a dye diffusion experiment, (b) carbonate chemistry in the Controlled Experimental Ecosystem (CEE), (c) transfer of trace metals and hydrocarbons by isotopic tracer and (d) monitoring of trace metals and hydrocarbons.

OCEAN PHYSICS DIVISION

P.W. Nasmyth - Chief of Division

The Ocean Physics Division has increased slightly to a total of thirty-nine permanent scientific and technical personnel of which seventeen are professional scientists. A number of potentially far-reaching changes in emphasis have been made in the program of the division.

The most significant of these changes has been the planning and initiation of several projects relating to the effects of the environment on, and the environmental effects of, oil and gas exploration and mining activities in the Canadian Arctic. Planning is still in a formative stage and the level of funding is uncertain, but it seems probable that most of the sections of the division will become involved in Arctic activities over the next year or two. One new section - the Arctic Marine Science Section - has been formed to help carry the anticipated load. So far only the section head - Mr. Allen R. Milne - has been appointed, and his task for the next year or so will be to coordinate and manage environmental studies in the Beaufort Sea.

With fall freeze-up, 1973, the main experimental program in Babine Lake was successfully concluded. Resources will be shifted during the coming year to expand the effort in B.C. coastal waters.

1973 has seen some consolidation of scattered Ocean Physics forces. The Coastal Zone Oceanography section has moved from West Vancouver to Pat Bay where they have joined Offshore Oceanography, part of Numerical Modelling and some components of other divisions. By February, essentially all of Ocean Physics will be located at Pat Bay except the Frozen Sea Research Group and Dr. P.B. Crean and Mr. P. Richards, Numerical Modelling, who remain in Vancouver for ready access to the UBC computer.

The activities of each section are reported separately in the following pages.

COASTAL ZONE OCEANOGRAPHY SECTION

D.M. Farmer - Head

W.H. Bell
R.H. Bigham
L. Egan (Administration)
R.E. Forbes
K.A. Gantzer
L.F. Giovando
R.H. Herlinveaux
R. Hlady
J.H. Meikle
L.A. Spearing
J.A. Stickland
S.E. Wilson

This year Coastal Zone Oceanography moved from the Pacific Environment Institute in West Vancouver to the Pat Bay site near Victoria. This move occurred right in the middle of a very full field season but was carried out over a period of two months without serious disruption to work.

Skidoo with electronic sleds and winch sled was used for data collection at weather stations on Babine Lake, winter 1972-73

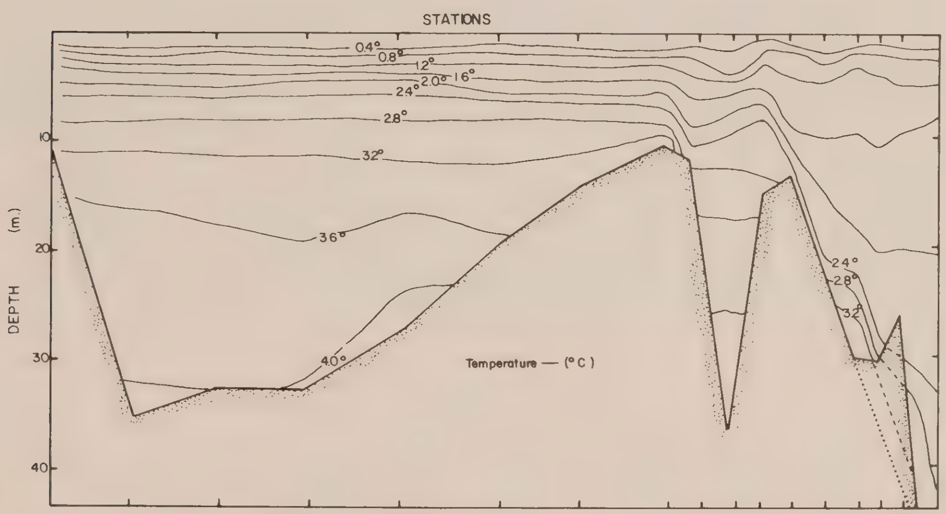
Babine Lake Project

The section concentrated its main effort on the concluding phase of the Babine Lake project, undertaken at the request of Fisheries Research Board in connection with their salmon enhancement project. Nearly everyone in the group has been actively involved in the field work and the program has produced what we believe to be the most comprehensive year-round record of physical data ever collected in a lake of this size.

Winter temperature measurements taken beneath the ice revealed a number of remarkable features. We found that temperatures in the north arm of the lake were significantly warmer than elsewhere, a result we attribute to the insulating effect of an early ice cover. We mapped the detailed temperature structure of this warmer denser water as it spilled into the main basin.

The early spring solar radiation penetrated the ice and warmed the water beneath, producing a unique example of penetrative convection which we followed to a depth of seventy-two metres. This phenomenon occurs widely in nature but is very hard to study. The observations, which are free from the complicating effects of atmospheric interaction, have enabled us to verify in nature conclusions about this process that have been reached on the basis of laboratory experiments. Thermistor chains moored beneath the ice yielded a detailed picture of the growing convection and we have directed much of our data analysis effort toward the interpretation of these results.

Of special interest are the detailed temperature records of the winter-summer and summer-winter periods of transition in thermal structure. We had many more instruments in the lake than last year; some thermistor chains have been left under the ice for the 1973-74 winter.



A temperature section taken under the ice of Babine Lake, March 5, 1973. Warmer water trapped in the North Arm is seen spilling over a sill into the main basin at right.

Howe Sound Program

The program of monitoring currents in Howe Sound was continued throughout the year from two adjacent buoys at a station located to the north of the sill. Instruments for measuring conductivity, temperature, current speed and direction were suspended beneath the buoys at various depths (mostly near-surface) for various periods of time. An attempt to gather wind data at the same location was unsuccessful due to instrument failures. Reduction of this data, and that from previously-occupied stations, was commenced. Bathymetric soundings were made in the vicinity of the sill to confirm previous information about the contours in that area. A study of the available historic data for Howe Sound was undertaken to examine the phenomenon of deep water exchange in the basin behind the sill. A selfcontained salinity-temperature-dissolved oxygen-depth recorder was obtained, and made operational, to permit more rapid monitoring of the oceanographic parameters in Howe Sound. (Bell)

Arctic Studies

The Coastal Zone Section continued to provide oceanographic support to Defence Research Establishment, Pacific, in two Arctic operations this year. Observations were taken in Lancaster Sound, Barrow Strait and Wellington Channel. During the spring we operated from an ice camp and took a number of oceanographic time series. We also took current measurements using a hydraulic hose to provide fixed orientation and so avoid the magnetic compass problems usually encountered at these latitudes. This is a new technique and proved very successful.

During the summer, further measurements (currents, ice-drift, etc.) were taken from the CCGS SIR WILLIAM ALEXANDER in Wellington Channel, Barrow Strait and Lancaster Sound. (Herlinveaux)

Task Forces

Several intensive studies were made for environmental task forces including oceanographic reports on the effects of the bulk-load facility at Roberts Bank, and on the proposed extension of Vancouver International Airport. Advice was given on oceanographic conditions relevant to sub-marine outfalls near Nanaimo and in the Qualicum-Northwest Bay area, and elsewhere. (Giovando)

FROZEN SEA RESEARCH GROUP

E.L. Lewis - Head

J.D. Bradbury
** J.W. Butcher (Computing Services)
* K. Fujino (visiting scientist)
** A. Koppel (Survey Electronics)
R.A. Lake
A.E. Moody
S.W. Moorhouse
R.G. Perkin
D.L. Richards
R.B. Sudar
J.A. Sutherland
L.E. Thirkell (Administration)
E.R. Walker

* Left in 1973.

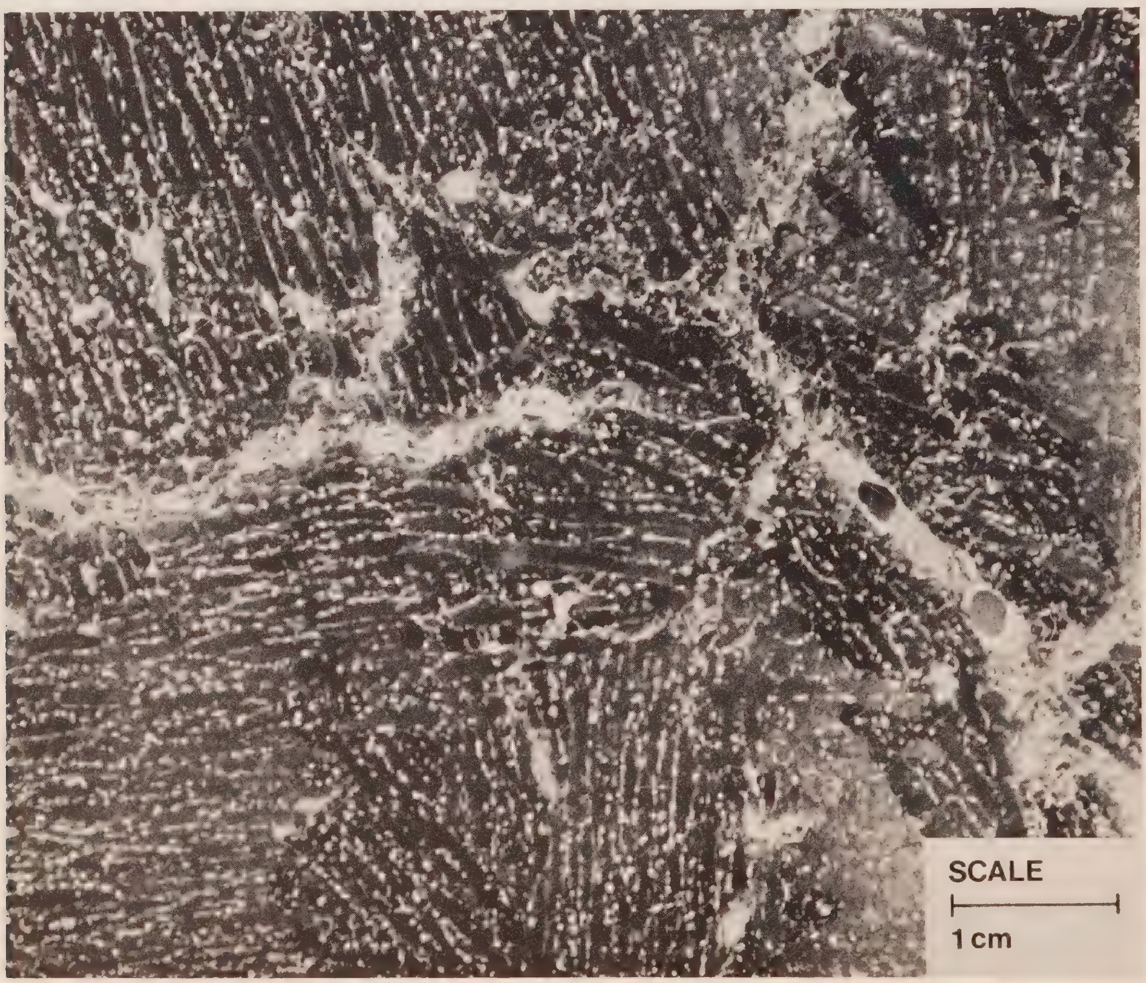
** Joined in 1973.

Two field operations in Greely Fiord (80° 36'N, 79° 35'W) during the year were directed towards the main study of seasonal changes in Arctic fiords. The March/April visit determined salinity, temperature and dissolved oxygen in d'Iberville and Greely Fiords. Convection at the ice/water interface and beneath a newly-opened lead was studied together with the propagation of internal waves along the extreme density gradient at the bottom of the convective layer beneath the growing sea ice.

In June 1973 the field party arrived three weeks before commencement of the annual runoff and prepared to gauge the flow of rivers fed by snow-melt in the surrounding hills. This was done in co-operation with the Water Survey of Canada and measurements were made using a bubbler water level system, a tide gauge, and time lapse photography of vertical scales in the stream. It was noted that permafrost conditions in the stream bed and melting during runoff made water height measurements questionable as a measure of stream flow. Cameras were also installed to look at the iceberg production from the end of the local glacier and a small automatic meteorological station was installed at the base. Tapes from all these automatic recording instruments were recovered in August of 1973 as was a ten-month tidal record which is presently being analyzed and shows interesting periodic fluctuations apparently not associated with normal tidal cycles.

The work on the freezing point of sea water at elevated pressures was completed giving a value for $\partial T/\partial p$ of 0.00759 °C/bar independent of salinity in the range from 27-35°/∘∘.

The major effort this year has been the development of a current measuring system for deployment in ice-covered waters. The direction-determining vane of an Aanderaa current meter has been removed and replaced with a small vane containing a magnet causing the compass inside the pressure case to track. Direction is measured by a gyroscope during the installation or by relation to the ice sheet for near surface measurements. The information is telemetered to a central collecting point by sonic and radio links as well as being recorded internally. This project is continuing with initial field deployment scheduled for 1974. We have completed one series of experiments on the direct calibration of an in situ CTD system dispensing with the use of a bench salinometer. A report is in preparation. Effort is being expended to improve the timing of automatic camera systems to reduce the effects of temperature change. This development will include the ability to switch on after say a nine-month lapse.



Drainage channels in sea ice. Shown is a thin (1 mm) horizontal slice of ice viewed between crossed polaroids. The wide irregular white bands are the drainage channels and anomalies in the regular crystal structure of the main ice mass.

Various studies have been made in support of the Department's interest in specific northern industrial developments in the mining and oil/gas fields. A survey of methods presently in use to calculate salinity from in situ temperature, conductivity and pressure measurements was published.

Dr. K. Fujino, visiting scientist from the Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan, returned home in October after a little over two years with the group.

NUMERICAL MODELLING SECTION

R.W. Stewart - Head

P.B. Crean
M. Foreman
R.F. Henry
P.J. Richards (Computing Services)

Following the addition of a further 25-channel, one-dimensional model of the northern passages to the existing combination of one and two-dimensional numerical schemes simulating the Strait of Georgia/Juan de Fuca system, final adjustments are now being made of the complete barotropic numerical model of the tidal cooscillations in the waters between Vancouver Island and the mainland. Elevations of the water surface, corresponding to the observed ocean tide, are prescribed at only two boundary openings, Johnstone Strait and the seaward end of Juan de Fuca Strait. Data from an intensive program of current meter observations over two cross-sections, located in the vicinities of these openings, have recently become available and afford a valuable check on the overall performance of the model. Quadratic friction, field acceleration and geostrophic terms are included in the equations of motion.

The tide entering the system from the north critically affects the reflection, in the northern part of the Strait of Georgia, of the Kelvin wave originating at the southern boundary opening, and hence affects the distribution of amplitude and phase in the semi-diurnal degenerate amphidromic region in the inner part of Juan de Fuca Strait. This in turn influences the tidal regime in the adjoining Puget Sound system.

A number of interesting results associated with the inclusion of the field accelerations in the momentum equations have been obtained. These include: (1) the effect on mean sea level in the Puget Sound system deriving from the curvature of the flow field around the southern end of Vancouver Island, and (2) evidence of a significant net transport over a tidal cycle northward on the mainland side of the islands which lie between the Strait of Georgia and Juan de Fuca Strait.

Net flows of similar origin constitute an important feature of the computed velocities in the several tidal rapids located in the northern passages.

Combination of one and two-dimensional numerical models of the Georgia-Fuca System

A one-dimensional seiche model of Babine Lake was completed. Observed seiche frequencies coincided with computed frequencies and the model indicated resiting of current meters was required in order to record the second seiche mode.

Theoretical studies were carried out to develop techniques for simulation of open boundaries, in order to reduce the area of ocean which must be included in tsunami and storm surge models.

Work has begun on modelling the formation of surface boundary and underlying convecting layers due to isolation in water covered by ice. A preliminary storm surge model of the Beaufort Sea is being operated and developed further.

OFFSHORE OCEANOGRAPHY SECTION

J.F. Garrett - Head

K.B. Abbott-Smith
C. de Jong
A. Hartley (CELL)
H.W. Hansen
L.S. Kuwahara
E.L. Luscombe (CELL)
E.W. Marles
B.G. Minkley
D.B. Smith (Computing Services)
S. Tabata
R.E. Thomson

Most of the effort of the Offshore Oceanography group during 1973 has been directed towards exploitation of existing data and preliminary development of new techniques, as described in the following.

Weathership Oceanography

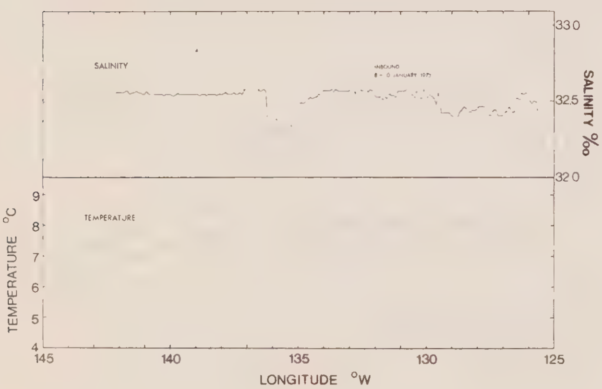
The oceanographic time series at ocean station P (50°N, 145°W) was continued for the seventeenth year, with oceanographers from Offshore Oceanography or Ocean Chemistry aboard for seven of the nine patrols. Physical oceanographic data was published in data report form, bringing the number of volumes in the series to fifty-six. A magnetic tape archive containing all observed values from bottle and STD casts at station P and on line P, arranged in chronological order, became operational and should greatly improve the accessibility of the data. (Garrett)

Oceanography Along Line P

Considerable effort has been put into interpreting data taken along line P between Esquimalt and station P, which includes samples and continuous recordings from the surface and XBT and STD casts at particular locations.

Sea surface temperature measurements along line P during 1973 showed that while the winter temperature was generally higher, (approximately 1°C) than it was during the previous winter, the summer temperature was lower, by approximately 1°C than during the previous year. The cooling trend that started during late spring is continuing.

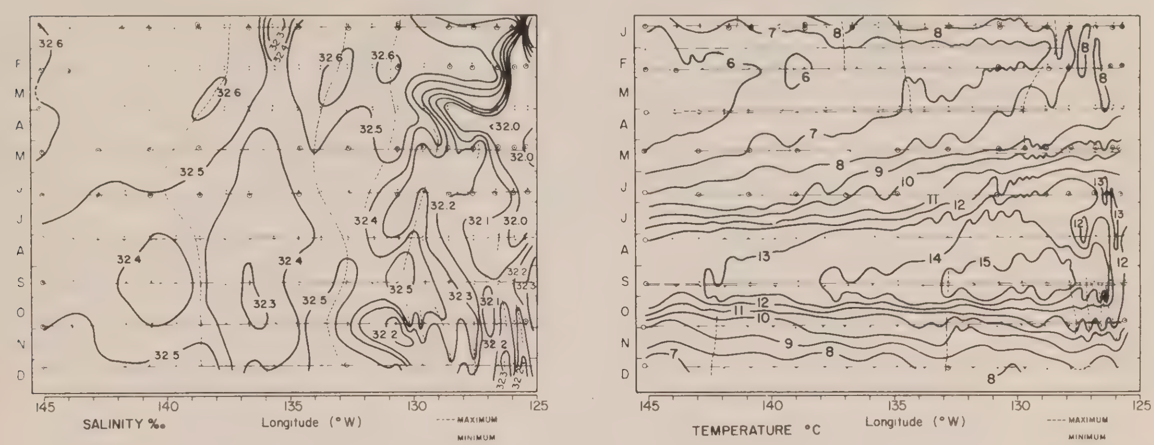
The winter temperature minimum ranged from approximately 6°C at station P to 8°C off the coast of Vancouver Island, while the summer temperature maximum ranged from approximately 13°C at station P to 15°C off the coast. The location of the maximum temperature during the summer of 1973 was closer to the coast, by approximately 100 miles, than in the previous year. As in previous years, the line P temperatures showed numerous relative maxima and minima, the most conspicuous feature being present in winter about halfway along the line.



An example of a record of salinity and temperature observed continuously at a depth of 3 meters along line P between Victoria and ocean station P (50°N, 145°W). Note the well defined relative minimum salinity and relative maximum temperature at about 136° west longitude.

After several years of frustrated effort, attempts to measure "surface" salinity continuously have finally succeeded and data is now regularly being obtained from one of the two weatherships. In the past, surface salinities were obtained from salinity determination from bucket samples. During the past two years surface salinities were determined from samples from the sea water loop with the intake located 3 m below the sea surface, as well as from bucket samples. Salinities obtained from the sea water loop yielded more consistent results than did those from bucket samples. Further, comparison of salinities obtained at corresponding locations on the outgoing voyage of one ship and the incoming voyage of the other ship (the samples were taken within at most three days apart at each location) provided more consistent results also.

As a result of improved quality control of the surface salinity determinations, it has been possible to resolve the fine features of the salinity variation along line P. The data obtained during 1973 clearly showed a relative minimum in salinity halfway along the line. This feature was particularly conspicuous during the winter and persisted for one year, at least. The origin of this water is unclear and attempts are being made to explain it. (Tabata)



Salinity (°/oo) and temperatures at a depth of 3 meters along line P during 1973. Hydrographic stations are indicated by o, surface samples by •. Dashed lines indicate times when continuous observations were made. Note the persistence in the occurence of relative maxima and minima during the entire year.

Analysis of subsurface data taken near line P by the weatherships CCGS QUADRA and CCGS VANCOUVER and by CFAV LAYMORE during an intensively sampled period in May 1972 indicated a strong northward flow off the B.C.-Washington coast, but also showed significant temporal variations at most depths. It was possible to qualitatively relate observed changes in the depth of the surface mixed layer to surface wind changes, with a response time of less than a day. At greater depths, temporal variations in the depth of surfaces of constant salinity could be largely described in terms of tidal oscillations at the K_1 and M_2 frequencies.

Another result of the same work was the discovery of a well defined region of large high frequency vertical variability of temperature, apparently marking the area of mixing of two water masses. A detailed numerical analysis of the STD data collected in the past along line P is now being conducted in order to ascertain the spatial extent and intensity of this small scale temperature variation in the vertical. It is hoped that this will give an indication of the spatial extent and variability of the northward coastal flow and of the vigour of the mixing of this flow with the eastward moving "West Wind Drift". (Thomson)

Variance of temperature about the mean vertical temperature profile, due to small scale temperature structure, for the part of the water column between 300m and 1500m below the surface. The larger values are thought to indicate a region of mixing between two water masses.

Variation of Monthly Mean Sea Level Along the Pacific Coast of Canada

In conjunction with the study of ocean climate an examination of the anomalies of monthly mean sea level and sea surface temperature along the Pacific coast of Canada was begun. By anomaly is meant the difference between the monthly mean value and the long-term mean (in the present case 22-year mean (1950-71)). The use of anomalies suppresses the usual annual variation in the data series.

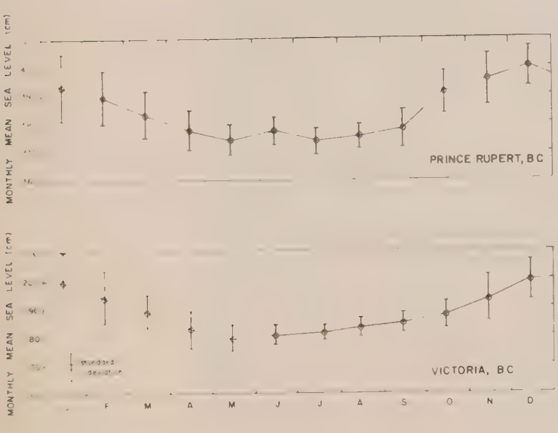
The data from the following stations were examined: Victoria, Vancouver, Point Atkinson near Vancouver, Tofino along the west coast of Vancouver Island, Alert Bay at the northern end of Vancouver Island, and Prince Rupert.

The results of the spectral analysis of the data were:

- Most of the energies of the anomalies were concentrated in the low frequency band, between 0 and 10^{-1} cycle/month and more specifically between 2×10^{-2} to 4×10^{-2} cycle/month.
- There was no significant periodicity in the data. There is, however, a suggestion of a periodicity of approximately 1.2 years.

- The coherence between the anomalies at Victoria and the rest of the stations except Prince Rupert is very good, the magnitude being well above 0.9 at all frequencies. For Prince Rupert, the coherence generally ranges from 0.6 to 0.8.
- There is generally a good phase agreement (within 10°) at all frequencies between Victoria and the rest of the stations except Prince Rupert where a difference as large as 40° occurs.
- The coherence between the anomalies of one station and the others, except Prince Rupert, is so good that it should be possible to fill the gap in the data of one station by that of another by the regression method, thereby lengthening the data series. The re-analysis of data from the longer series should provide a more reliable spectral estimate.

Examination of the anomalies from these stations has also indicated that for some stations, mainly Tofino, Vancouver and Point Atkinson, discrepancies occur for some earlier data. Such discrepancies could have resulted from instability of the land on which instruments were placed but it is more likely that there had been a change in the reference level of the observational site. Attempts are now being made to seek causes of these discrepancies. (Tabata)



Long term monthly mean sea level heights (cm) for 1950-71 at Victoria and Prince Rupert, B.C. There is an annual range of more than 20 cm in the levels. In the year by year analysis this annual cycle would be suppressed by subtracting the long-term mean from the mean for the particular month and year being examined, yielding an anomaly.

Planetary Waves

Continuing work on the propagation of waves of planetary scales (wavelengths of hundreds to thousands of kilometers) over rough bottom terrain has shown that these waves lose energy to scattering while passing over such terrain. Also, and more importantly, they can have their phase speeds significantly reduced. Numerical values for the phase speed changes have been calculated for the topography of the Eastern North Pacific. (Thomson)

Longshore Currents Off the Fraser River Delta

A theoretical study into the generation of a longshore current by breaking internal waves in a two-layer fluid has been completed and applied to the nearshore region of the Fraser River delta. Use of observed topographic, water and internal wave parameters in the generalized theory indicates that a longshore current of a few knots having an offshore extent of 2-3 kilometers is easily possible, and that this current may account for the persistent flow recently observed in this area. (Thomson)

Saturation of Vapour Pressure Over Liquid Water

Oceanographers and meteorologists make wide use of saturation vapour pressure for a variety of purposes including that of estimating evaporation over bodies of water. In the past, the values of saturation vapour pressure were frequently obtained from tables in reference books and handbooks. However, when large numbers of values are required it is more common nowadays to compute each value by using a digital computer. If the volume of computations is very large, then the demand for computational efficiency has to be considered as well. A formula,

$$\log_{10} e = 8.4292661 - 1.8271784 \left(\frac{10^3}{\theta}\right) - 0.07120827 \left(\frac{10^3}{\theta}\right)^2$$

where e is the saturation vapour pressure in millibars,

θ is the absolute temperature ($^\circ$K = T + 273.15) where

T is the temperature of air in $^\circ$Celsius,

is proposed which will yield values of vapour pressure that are sufficiently accurate for most purposes and that can be computed with considerable savings in computational time. (Tabata)

Data Catalogues

As part of an effort to improve the accessibility of data for use in environmental studies, two catalogues have been prepared listing all discoverable data for particular regions. One covers the Strait of Georgia and Juan de Fuca Strait and consists of two volumes, the first devoted to physical oceanography and the second to biological oceanography. The other catalogue covers hydrographic (bathymetry and tides) and oceanographic data for some seventeen estuaries on the British Columbia coast. Both catalogues are available as Pacific Marine Science Reports. (Marles)

Drifting Buoys

The imminent availability of low cost and low power satellite communications and tracking makes it practical to collect oceanographic information with expendable drifting buoys. A program has been started to develop such a system for use in studies of the heat budget of the upper ocean and the exchange of heat between the ocean and atmosphere. An experiment using these buoys is planned for January 1975, using the Nimbus F satellite.

The First GARP Global Experiment in 1977-78 will rely on drifting buoys for surface meteorological data in sparsely populated regions with persistent cloud cover, notably the region between 50° and 65° south latitude around Antarctica. Active involvement in the planning for this has included carrying out studies to determine what kind of array might be obtained by deploying the buoys from the Antarctic supply vessels of various nations, and preparing a summary of the drifting buoy development programs underway in other countries. (Garrett)

A modified kayak and the long plastic cylinder are two of the surface hulls being considered for use with low-cost satellite-tracked drifting buoys for measurements of ocean currents.

BEAUFORT SEA PROJECT

A.R. Milne - Project Manager

Intensive planning and some logistic preparations for the Beaufort Sea Project were carried out in the fall of 1973. The project is a set of twenty-nine environmental studies scheduled to be completed by May 1975, in order to provide an assessment of the impact of offshore exploratory drilling planned for the summer of 1975.

Documentation of the studies must be made available early in 1975 to the Arctic Water Oil and Gas Advisory Committee which has jurisdiction over Arctic drilling operations.

The project area is defined as the summer open-water area extending from the Yukon-Alaska border in the west to Cape Parry in the east.

All the environmental studies in the Beaufort Sea project are a response to the following questions:

1. What in the environment can be damaged (e.g. wildlife, climate)?
2. What are the mechanisms by which the damage is effected (e.g. movements of pollutants by wind and ocean currents)?
3. How are environmental changes identified (e.g. baseline studies to determine existing conditions)?
4. How can drilling operations be carried out to minimize environmental damage and what effect can the environment have on the drilling operations (e.g. ice movement, bottom scouring, etc.)?
5. How does one react to a polluting incident (e.g. containment and clean-up)?

The studies are grouped into subject areas which include wildlife, marine life, baseline pollutants, physical oceanography, meteorology, environmental geophysics, sea ice and oil clean-up studies.

Responsibility for the completion of each study has been assigned to an investigator within the Department of the Environment, with the exception of the environmental geophysics studies, assigned to the Department of Energy, Mines and Resources. In general the studies are an acceleration of work already being carried out, but which up to now has had minimal resources. Project funding is anticipated early in 1974.

OCEAN MIXING SECTION

P.W. Nasmyth - Head

L. Beauchemins (CELL)
G.W. Chase

A.E. Gargett
R.C. Teichrob

Over the past several years a series of ocean turbulence/ microstructure experiments has been carried out in the shelf and slope waters of British Columbia and Washington State. In January-March 1973 a more extensive operation was undertaken to obtain comparative data from other ocean areas. Five locations were sampled for approximately twenty-four hours each along a track running almost due west from Cape Flattery, then south to Hawaii and return. Two of these locations - one outbound and one inbound - covered part of the same area sampled in previous operations.

From a visual watch during recording at sea, the occurence of turbulence of all stations was higher than that observed during the 1972 cruise in the Cobb Seamount area, but in no case as high as during the 1967 or 1969 cruises. As yet we have no satisfactory explanation for the differences. One of the more widely accepted theories for the existance of turbulence below the main thermocline is that internal waves are generated by a coupling of energy from surface waves (and therefore directly related to sea state and surface weather) and may then break, forming patches of turbulence at some later stage at almost any depth. 1972 results were consistent with this picture. Surface weather was unusually good (considering the time of year) and the occurrence and intensity of turbulent activity was correspondingly low. During the latest cruise, however, on at least one occasion low levels of turbulence were observed at all depths immediately following a fairly intense storm with winds ranging up to sixty knots for two days. If turbulence at depth is a result, (even though indirect), of surface activity, one would have expected more.

Some preliminary checking of data obtained on the 1973 cruise has been carried out, but detailed analysis of the large volume of data has been postponed until after the group moves to Pat Bay. In the meantime attention has been concentrated on projects involving data from the 1972 cruise.

A major effort, completed by the end of 1973, was analysis of the horizontal correlation of vertical temperature structure having scales of the order of meters, using temperature and conductivity signals recorded during the cycling mode of operation of the towed body system. The cycling mode causes the body to carry out a sawtooth path through the water and, if the cycle is sufficiently uniform, points at the same depth on consecutive up-cycles (or down-cycles) have a fixed horizontal separation D = horizontal extent of a total cycle (up and down).

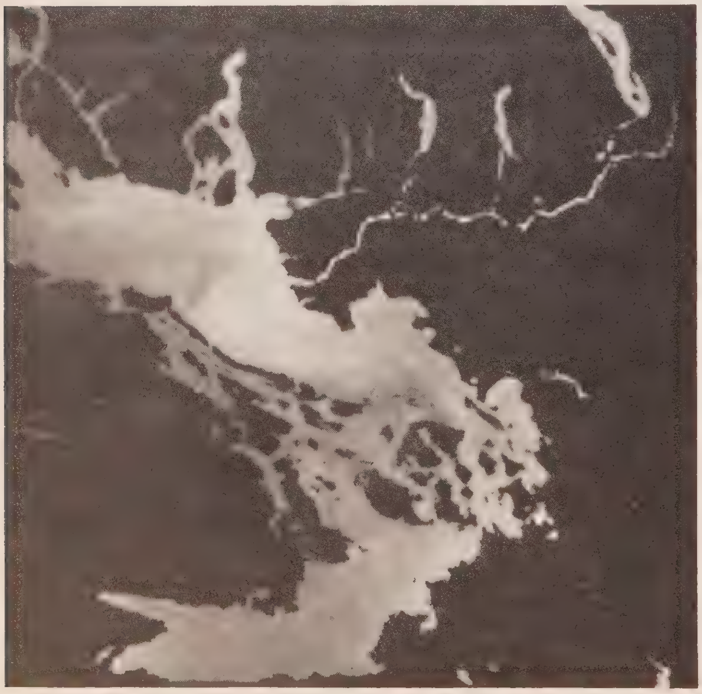
Thus, from quasi-vertical profiles, it is possible to estimate a strictly horizontal correlation

$$R(D) = \overline{T_n \cdot T_{n+1}} \;/\; (\overline{T_n^2 \cdot T_{n+1}^2})^{\frac{1}{2}}$$

where T_n and T_{n+1} refer to temperature along consecutive up-(down) cycles and the average is over the whole extent of the cycle.

By using other non-consecutive pairs of up-(down) cycles, estimates of the correlation coefficient can be obtained for distances up to mD, where m = total number of cycles in one sample. Analyzed in this way, the 1972 data form a continuium, from samples with extremely high correlation over the 1-2 km horizontal range which can be examined, to samples with severe loss of correlation over the minimum horizontal spacing, D. Fully 20% of the available samples are poorly correlated with distance: for such samples, analysis of the change in T/S properties along isopycnal surfaces suggests that this is due to some complex frontal and/or interleaving mechanisms, rather than to internal waves.

During the latter part of 1973, two other projects were started: one, to determine what relation (if any) there is between occurrence of "turbulence" and the local mean gradients of T, S and p, and a second to produce some form of comment on the very low levels of velocity turbulence observed during both 1972 and 1973 cruises.



A picture from the ERTS-1 satellite of the Vancouver/Victoria area computer-processed to show small radiance variations over bodies of water. Land areas appear black. Brighter areas indicate water containing more light scatterers, mostly due to presence of river silt.

REMOTE SENSING SECTION

J.F.R. Gower - Head
(under contract)

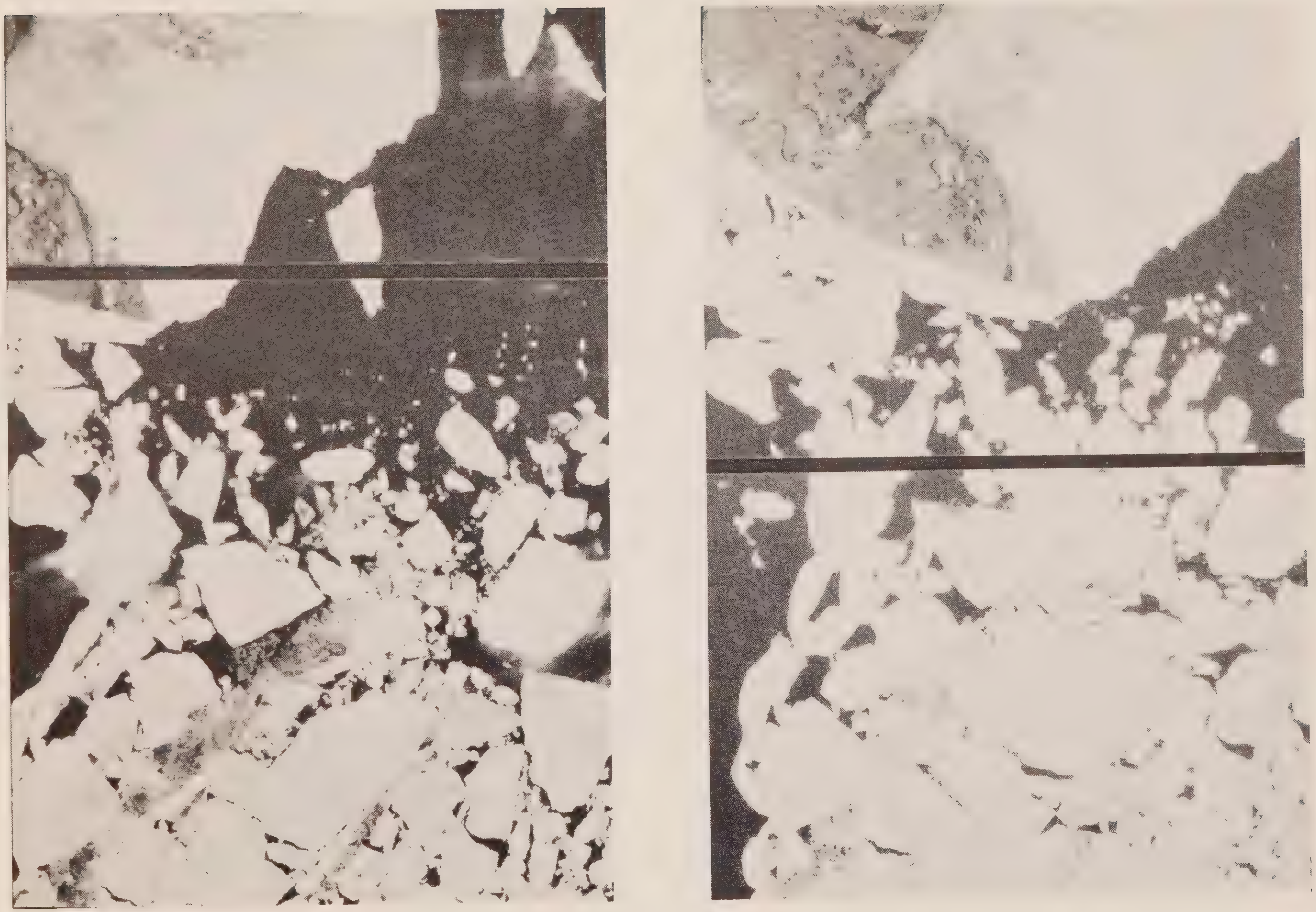
I. Daniel (project contract)
B. Isherwood (project contract, at UBC)
D. Truax (project contract)
J.S. Wallace (from Aug.1)

A variety of remote sensing techniques were evaluated during the year with continuing projects in satellite imagery, airborne spectroscopy, infrared sensing and inertial and radar navigation systems. A number of shorter projects included time lapse photography for floating debris counts, "fixed base" stereo photography, use of diazo transparencies for forming colour composites, and evaluation of ERTS-1 satellite imagery for Arctic coverage. This last study is now being continued in conjunction with the Beaufort Sea Project. General uses of the ERTS-1 satellite were also investigated by B.C. Remote Sensing, a group supported by the Canada Centre for Remote Sensing (CCRS). The group was in close communication with MSD (Pacific) and several preliminary studies were carried out jointly with them.

Programs for digital analysis of the ERTS image data were developed and provided some of the first evaluations of taped data and its various problems and advantages. Detection limits for small radiance changes over a body of water (due for example to changes in salt or algae content) were investigated. A report describing enhancements of the data and showing the effect of averaging is in preparation. Data was also obtained from satellite passes in which the scanner gain was increased, by special arrangement with NASA.

The development of a multichannel spectrometer for airborne measurements of water colour and possibly fluorescence, continued with Dr. G.A.H. Walker, Astronomy Department, UBC on two contracts. The first demonstrated the technique of using an integrated microcircuit chip containing 256 silicon diode light detectors and their sampling circuitry as the basis of a simple, compact multichannel spectrometer. Under the second contract an operational unit with data processing and acquisition electronics is being built and is now undergoing bench tests.

The scanning PRT-5 system was flown during the summer over Babine Lake and provided a map of lake surface temperatures when corrected for atmospheric effects using surface spot measurements made from a boat. The CCRS Falcon Fanjet aircraft also flew over the lake and provided colour photography and imagery from a thermal scanner. The thermal imagery showed several temperature fronts and plumes. This data will be valuable in the physical limnological study of the lake.



Movement and breakup of ice as seen by the ERTS-1 satellite. The tip of Cape Bathurst and ice in Amundsen Gulf is shown on June 16, left, and June 18, right. The horizontal gaps are introduced by the image processing.

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent

F.S. Green, Assistant Marine Superintendent (deck)

D. Marr, Assistant Marine Superintendent (engineering)

The Pacific Region Ship Division provided the usual on-going support to all 1973 hydrographic and scientific programs and is happy to report no serious incident interrupted this service.

CSS PARIZEAU

Master, A.G. Chamberlain

Chief Engineer, B.N. Aaron

Following annual refit at B.C. Marine Shipbuilders Ltd., Vancouver, B.C., PARIZEAU served FRB (Biology), MSD (Tidal and Current), DND-DREP (Equipment Testing), MSD/EMR (Resource Charting - West Coast and Western Arctic), MSD (Ocean Chemistry), UVic (Biology). Current metering and the West Coast and Western Arctic projects were the highlights of this activity. Extremely bad ice conditions were encountered in the vicinity of Point Barrow on entry to the Arctic and some shell damage resulted.

CSS WM.J.STEWART

Master, K.J. Sjolholm

Chief Engineer, J.D. Henderson

Following winter decommission and annual refit WM.J.STEWART was engaged in hydrographic survey from April 16 to October 12 in the areas of Strait of Georgia, Howe Sound and Chatham Sound (Skeena River delta area).

CSS VECTOR

Master, T.P. Scanlon

Chief Engineer, G.W. Clouston

Following annual refit VECTOR supported the programs of IOUBC (Physics, Chemistry, Biology, Instrument Testing), MSD (Offshore Oceanography, Tidal and Current) and UVic (Biology) in B.C. coastal areas.

CSS RICHARDSON

Master, C.M. McIntyre | Chief Engineer, I.N. Henderson

RICHARDSON supported the activities of Hydrography (Revisory Survey), assisted the PARIZEAU Resource Charting program and alternated with REVISOR as surface vessel to the PISCES IV program.

CFAV LAYMORE

Master, M.J. Dyer | Chief Engineer, T.J. Taylor

LAYMORE repeated her role as support ship to the Pacific Region scientific community during 1973 under the usual terms of MSD's 75% cost contribution. During this period LAYMORE served UVic (Ocean Survival, Biology), PEI (Ecology, Biology, Chemistry), IOUBC (Physics, Geophysics), MSD (Chemistry, DREP (Equipment Trials), WCUMBS (Biology).

MV RADIUM EXPRESS

Master, J. O'Sullivan | Chief Engineer, K. Jensen

1973 marked the second year of this Mackenzie River charter operation and the first year of the new five-year charter agreement. The hydrographer-in-charge of this program expressed utmost satisfaction with the arrangement.

PISCES IV

Chief Pilot, D. Harrison | Pilot, P.S. Legallais

The highlight of this year's operation was the transport of PISCES IV and staff from Pat Bay to Shearwater, Nova Scotia. This unit played the principal part in locating and raising a military helicopter which had crashed and sunk approximately thirty miles off the coast of Nova Scotia. The charter of a mothership, currently under construction, will considerably improve the range and capability of the submersible.

CSL REVISOR

REVISOR performed a dual role as support vessel to the submersible activity and a revisory survey vessel in southern B.C. coastal areas. This craft continues to operate very reliably and hopefully the multitude of mechanical failures which originally plagued the division are in the past.

LAUNCHES

The Region's launch fleet rendered good support service to hydrographers and scientists. Launch TERN, unfortunately, proved a continuing problem for the shore party hydrographer and the depot maintenance staff. Equipped with a new engine and total refit it is hoped this launch will turn in an improved performance in 1974.

The submersible Pisces IV which has joined MSD Pacific fleet.

MANAGEMENT SERVICES

A decision was made in the latter part of 1973 to combine the duties of Administration Division with those being carried out by the Facilities and Engineering Planning Unit of Ocean Engineering. This move allows integration of long range planning studies and day-to-day administrative planning.

Provision has been made for increased operational and maintenance responsibilities for the Patricia Bay site.

A program for having the accounting system computerized has been written and test runs have been successfully completed. This project will be pursued and hopefully the complete computerized system can be fully operational for fiscal year 75-76.

Temporary offices inside Patricia Bay hangar.

TASK FORCE, COMMITTEE AND SIMILAR ACTIVITIES

R.W. Stewart

Advisory Committee on Oceanic Meteorological Research (ACOMR) of WMO - Vice Chairman.

Beaufort Sea Project - Chairman, Steering Committee.

Canadian Committee for GARP.

Canadian Geophysical Union - Canadian Association of Physicists.

IAMAP - IAPSO - SCOR Working Group on Air-Sea Interaction.

International Council of Scientific Unions - COSPAR Committee on Space Research.

Joint Organizing Committee (JOC) of Global Atmospheric Research Program (GARP) - Chairman.

National Research Council - Advisory Committee on Physics.

National Research Council of Canada - Grant Selection Committee for Physics - Committee Chairman.

Pacific Region Board DOE.

Physical Oceanographic Commission of IAPSO - Chairman.

The Royal Society of Canada - Selection Committee (interdisciplinary).

The Sea Use Council (USA) - Vice-Chairman.

Steering Committee, Patricia Bay Ocean Institute - Chairman.

W.N. English

B.C. Research Ocean Engineering Centre Governing Board.

Beaufort Sea Project Steering Committee - Alternate to Chairman.

Beaufort Sea Proposal Drafting Group - Chairman.

Canadian Advisory Committee on Remote Sensing.

Canadian Committee on Oceanography.

Estuary Working Group of Pacific Region Board.

Intergovernmental Oceanographic Commission 8th Assembly - Canadian Delegation.

Pacific Region Board DOE - Alternate.

Pacific Subcommittee on Oceanography of CCO - Chairman.

The Sea Use Council - Alternate to DOE member.

Steering Committee, Patricia Bay Ocean Institute.

Working Group on Abatement of Pollution from DOE Ships - Chairman.

Working Group on Remote Sensing for Oceanography of the CACRS - Chairman.

HYDROGRAPHIC DIVISION

Anderson, N.M.

Aerial Hydrography Project Subcommittee of Oceanography Working Group.

Working Group on Remote Sensing for Oceanography of the CACRS.

Bolton, M.

Atlantic Tropical Experiment (GATE).

Canadian Institute of Surveying, Victoria Branch - Chairman.

Deputy Canadian Coordinator of the GARP.

Fisheries and Marine Strategic Planning Committee, Pacific Region.

National Hydrographic Survey Officers' Appraisal Board.

New Research Vessel Users Design Committee - Chairman.

Northwestern B.C. Environmental Study Group.

Pacific Subcommittee on Oceanography of CCO - Alternate.

Survey Technology Advisory Committee, BCIT.

Sandilands, R.W.

Board of Trustees Maritime Museum of B.C. - Chairman.

Hydrographic Committee, Canadian Institute of Surveying.

Workshop on Offshore Surveys for Mineral Resource Development.

Smithers, F.R.

Public Information Group, DOE, Pacific.

OCEAN CHEMISTRY DIVISION

Cretney, W.J.

Ph.D. Dissertation Committee - Mr. D. Green at UBC (Hydrocarbons).

Wong, C.S.

Advisory Committee - GEOSECS, Carbon Chemistry Panel.

CEPEX Chemical Advisory Committee.

Coordinating Committee on Environmental Issues.

GEOSECS Scientific Advisory Committee.

Marine Chemistry Committee, Pacific Region.

National Marine Chemistry (Standard) Group.

Ph.D. Dissertation Committee - Mr. D. Green at UBC (Hydrocarbons)

Ph.D. Dissertation Committee - Mr. P. Berrang at UVic (Trace Metals).

Working Group - International Commission on Water Quality.

OCEAN ENGINEERING DIVISION

Todd, N.A.

Project Management Team, Institute of Ocean Sciences, Patricia Bay.

Victoria International Airport Planning Review Committee.

OCEAN PHYSICS DIVISION

Farmer, D.M.

Babine Lake Steering Committee.

Inshore Oceanography Vessel Committee - Chairman.

Garrett, J.F.

International Council of Scientific Unions Committee on Space Research (COSPAR), Working Group VI, Panel A (Weather and Climate).

Instrument Committee, Northwest Regional Calibration Center.

Giovando, L.F.

DOE Steering Committee re environmental effects of the proposed expansion of Vancouver International Airport.

DOE Steering Committee re environmental study of Roberts Bank Development.

Pacific Committee of Military Oceanography.

Working Group on Environmental Baseline Study of the Lower Fraser Valley and Fraser Estuary.

Lewis, E.L.

Associate Editor Marine Science Communications.

Panel on Ice. Arctic Oceanography Subcommittee, Canadian Committee on Oceanography.

Subcommittee on Snow and Ice of Committee on Geotechnical Research of National Research Council, Ottawa.

Nasmyth, P.W.

IGOSS Group of Experts on Technical Systems Design and Development and Service Requirements - Chairman.

Tabata, S.

Scientific Committee on Oceanic Research (SCOR), Working Group 34 (Ocean Climate).

Thomson, R.E.

British Columbia Coordinating Climate Committee.

SHIP DIVISION

Geldart, E.N.

Pacific Region Resource/Survey Vessel Committee - Secretary.

Working Group on Abatement of Pollution from DOE Ships - Secretary.

Home away from home, Barrow Strait, April, 1973.

RESEARCH AND DEVELOPMENT CONTRACTS

		Total Amount
1.	Develop techniques for manufacture of thin film probes for measurement of fluctuations in water velocity. *Canadian Thin Films, Ltd.*	$24,600
2.	Develop specifications for a 16-channel, high capacity data acquisition system for PISCES IV submersible. *MacDonald, Dettwiler and Associates, Ltd.*	4,400
3.	Manufacture data acquisition system for PISCES IV according to specifications developed in 2 above. *MacDonald, Dettwiler and Associates, Ltd.*	46,523
4.	Develop and manufacture INS data acquisition system for use with inertial navigation system on PISCES IV or aircraft. *MacDonald,Dettwiler and Associates, Ltd.*	123,312
5.	Conduct a study of shear instability in the ocean and its importance in the generation of oceanic turbulence. *Dr. T.R. Osborn, University of British Columbia.*	20,036
6.	Conduct the second phase of a study of the dynamics of fiords and inlets of the British Columbia coast (continued from 1972). *Dr. G.S. Pond, University of British Columbia.*	15,185
7.	Carry out a study of remote sensing applications in hydrography and oceanography (continued from 1972). *Dr. J.F.R. Gower, Victoria, B.C.*	16,000
8.	Evaluation of two-media photogrammetry. *Dr. S. Masry, University of New Brunswick.*	4,000
9.	Inform and demonstrate to Canadian scientists the Japanese approach to problems in Arctic oceanography. *Dr. K. Fujino, Hokkaido University, Sapporo, Japan.* (Completed October, 1973).	10,000
10.	Under-ice photography and brine sample collection from stalactites. *Dr. H. Welch, University of Toronto.*	500
11.	Construction and field testing of a spectrometer suitable for airborne observations for the remote measurement of sea colour. *Dr. G.A.H. Walker, University of British Columbia.*	34,380

12.	A feasibility study of the monitoring of floating debris in the Strait of Georgia by time lapse photography. *Dr. P.I. Warrington, Victoria, B.C.*	$1,640
13.	Computer analysis of satellite and aircraft data. *Mr. I. Daniel, Victoria, B.C.*	4,950
14.	Analysis of spectrophotographs for water depth measurements. *Mr. D. Truax, Victoria, B.C.*	1,300
15.	Sampling oil pollution materials and making biological identification at Alert Bay and other sites in British Columbia. *Professor Tim Parsons, University of British Columbia.*	1,500
16.	Feasibility study on the application of mass spectrometry to routine quantitative analysis of trace metals in sea water by using metal chelates. *Dr. G.R. Branton, University of Victoria.*	1,248
17.	Preliminary investigation of seven beaches on southern Vancouver Island for evidence of oil pollution, especially persistent tarry residues. *Mr. A.H. Matheson, We Healdath, Environmental and Recreational Consultants.*	737
18.	To examine holdings of Neuston net tows at Scripps Institution of Oceanography, La Jolla; to collect tar balls from such biological samples and to record all descriptive data for future work in Ocean Chemistry Division; to collect Neuston net samples of pelagic tar on the Scripps ship THOMAS WASHINGTON, in the western Pacific Ocean. *Mr. D.R. Green, University of British Columbia Zoology Department.*	1,500
19.	To conduct a feasibility study for the exchange between liquid water and the ambient atmosphere above through a surface layer, in connection with Ocean Chemistry air-sea exchange program, and to submit a report on findings. *Professor R.N. O'Brien, University of Victoria.*	1,248
20.	To provide radiocarbon dating service for Ocean Chemistry Division. *Dr. A.D. McIntyre, B.C. Research.*	13,500

PUBLICATIONS

1973

Canada. Marine Sciences Directorate, Pacific Region, 1972 Annual Report.

Canadian Hydrographic Service, 1973: Proceedings Twelfth Annual Canadian Hydrographic Conference, Victoria, February 27 to March 1, 1973.

Ages, A.B., 1973: A numerical model of Victoria Harbour to predict tidal response to proposed hydraulic structures. *Pacific Marine Science Report 73-3.*

Anderson, N.M., R.D. Popejoy, F.A. Coldham, and M.V. Woods, 1973: An evaluation of mini-ranger positioning system. *Pacific Marine Science Report 73-11.*

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PERMANENT STAFF - 1973

DIRECTOR

Stewart, R.W.; B.Sc., M.Sc., (Queen's), Ph.D. (Cantab), FRSC, FRS, D.Sc. (McGill).

DEPUTY DIRECTOR

English, W.N.; B.A. (Brit.Col.), Ph.D. (California).

ADMINISTRATION DIVISION

Todd, N.A.; B.Sc. (Glasgow), M.A. (Carleton); Acting Chief of Division.

* Adair, E.E.S.
Coldwell, D.J.
Cotton, R.M.
Craton, M.I.K.
Crouch, R.W.
Crowell, D.B.
Egan, L.L.
Foreman, I.
Gleadow, P.M.
Gravel, J.N.J.
* Gutfriend, A.E.
Hackney, J.Y.
Hall, E.J.
Hartley, A.M.
* Lyon, S.A.
* Mitchell, F.V.
* McLellan, S.J.
* Mortensen, A.
Parsons, J.E.
Pimlott, S.K.
Stewart, A.M.
Thirkell, L.E.
Thomas, C.D.
Van Dusen, T.S.
Vinden, L.M.
* Walker, F.M.

HYDROGRAPHIC DIVISION

Bolton, M.; Regional Hydrographer.

Ages, A.B.; B.A.Sc., M.A.Sc. (Brit.Col.), P. Eng.
Ames, S.E.
Anderson, N.M.; Dip. AIT
* Banyard, R.
Bath, J.F.; Master, F.G.
Bell, R.D.
Bennett, K.M.
Brown, R.E.
Browning, P.C.
Campbell, I.J.; Dip. BCIT
Chivas, J.W.; Master, F.G.
Clark, D.J.
Clarke, E.B.
Coldham, F.A.
Coldwell, J.H.
Cooke, G.L.; Dip. NSIT
Coulter, E.M.
Curran, T.A.; B.A.Sc.(Brit.Col.)
Dobson, D.G.
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Eaton, G.H.; Dip. BCIT
Firth, C.
Fujino, N.S.; Dip. BCIT
Gregson, D.J.; Dip. BCIT
Harris, W.J.
Hermiston, F.V.
Highton, K.; Dip. BCIT
Hinds, E.W.; Dip. BCIT
Hlina, R.C.; Dip. BCIT
Holman, K.R.
Huggett, W.S.; Master, F.G.
Jones, T.; Master, F.G.
Korhonen, R.K.
Larkin, J.B.; B.Sc. (Prince Edward Island)
Lee, P.O.; Dip. BCIT
Lusk, B.M.; Master, 350 T
Lyon, A.G.
McIntosh, C.G.; Master, F.G.
Mortimer, A.R.; Master, F.G.
Nast, C.J.
O'Connor, A.D.
Patton, M.M.
Philp, A.R.
Pierce, R.A.
Plume, T.C.
Popejoy, R.D.
Rapatz, W.J.; B.Sc. (Victoria)
Raymond, A.R.; Dip. Algonquin College
Richardson, G.E.
Rogers, G.W.
Ryan, C.F.; Dip. RRE (England)
Sandilands, R.W.; Lt.RN (Retired)
Smithers, F.R.
Tamasi, C.R.; Dip. BCIT
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Taylor, W.R.; Dip. RCC
Thompson, L.G.
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Wigen, S.O.; B.A.Sc. (Brit.Col.), P. Eng.
Wills, R.; Master Mariner, F.G.
Woods, M.V.; Dip. BCIT
Yee, P.Y.; Dip. BCIT
Young, V.N.

OCEAN CHEMISTRY DIVISION

Wong, C.S.; B.Sc., M.Sc. (Hong Kong), Ph.D. (Scripps), Dip. Mar. Sc. (UNESCO); Chief of Division.

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Cornford, A.B.; B.Sc. (McMaster), Ph.D. (Brit.Col.)
Cretney, W.J.; B.Sc., Ph.D. (Brit.Col.)
Jackson, C.M.; B.Sc. (Victoria)
Pannekoek, W.J.; B.Sc. (Alberta)

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Butcher, J.W.; B.Sc. (Victoria), M.Sc. (Toronto)
Douglas, A.N.; B.Sc. (Victoria)
Johns, R.E.; B.Sc. (Victoria), M.Sc. (Brit.Col.)
Morgan, C.G.; B.Sc., M.Sc. (Alberta)
Richards, P.J.; B.Sc. (Brit.Col.)
Smith, D.B.; B.Sc. (Victoria)
Teng, K.; B.A.Sc., M.A.(Brit.Col.)
Todd, N.A.: B.Sc. (Glasgow), M.A. (Carleton)

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Bigham, R.H.
Bradbury, J.D.
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de Jong, C.
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Gargett, A.E.; B.Sc. (Manitoba), Ph.D. (Brit.Col.)
Garrett, J.F.; B.A. (Harvard), Ph.D. (Brit.Col.)
Giovando, L.F.; B.A., M.A., Ph.D. (Brit.Col.)
Gower, J.F.R.; B.A., M.A., Ph.D. (Cantab)
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Koppel, A.W.
Kuwahara, L.S.C.
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Marles, E.W.; B.Sc. (Victoria)
Meikle, J.H.
Milne, A.R.; B.A.Sc. (Toronto), M.Sc. (McGill)
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Walker, E.R.; B.Sc. (Manitoba), M.A. (Toronto), Ph.D. (McGill)
Wallace, J.S.

SHIP DIVISION

Geldart, E.N.;	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Regional Marine Superintendent.
Green, F.S.;	Master Mariner; Assistant Marine Superintendent (Deck).
Marr, D.;	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Assistant Marine Superintendent (Engineering).
Marston, J.C.;	Master, F.G.; Relief Master.
Thomas, P.;	Engineer 3rd Class Motor; Relief Engineer.

CSS PARIZEAU

Chamberlain, A.J.;	Master, F.G.; Master
Keene, R.W.;	Master, F.G. (X); 1st Officer
Mackie, D.E.;	2nd Mate, F.G.; 2nd Officer
Christie, J.N.;	Radio Certificate; W/O
Clarke, L.E.;	Supply Officer
Aaron, B.N.;	Engineer 1st Class Combined; Chief Engineer
Delany, W.G.;	Engineer 2nd Class Motor; Senior Engineer
Pride, L.G.;	Engineer 2nd Class Motor; 1st Engineer
Kyle, R.G.;	Engineer 2nd Class Motor; 2nd Engineer

CSS WM.J.STEWART

Sjoholm, K.J.;	Master, F.G.; Master
Smith, D.E.;	Master, F.G.; 1st Officer
Barboza, C.S.;	Mate, F.G.; 2nd Officer
Wheeler, M.G.;	Mate, H.T.; 3rd Officer
Palmer, S.;	Supply Officer
Henderson, J.D.;	Engineer 2nd Class Steam; Chief Engineer
Gibson, R.B.;	Engineer 3rd Class Steam; Senior Engineer
Conway, A.;	Engineer 4th Class Combined; 3rd Engineer

CSS VECTOR

Scanlan, T.P.;	Master, F.G.; Master
Fisher, E.G.;	Master, F.G.; 1st Officer
Easson, R.J.;	Master, F.G.; 2nd Officer
Clouston, G.W.;	Engineer 3rd Class Motor; Chief Engineer
Storer, T.H.	Engineer 3rd Class Motor; 1st Engineer
Pearson, R.;	Engineer 4th Class Motor; 2nd Engineer

CSS RICHARDSON

McIntyre, C.M.;	Master, 350 T.; Master
Henderson, J.N.	Engineer 4th Class Motor; Chief Engineer

CFAV LAYMORE

Dyer, M.;	Master
Taylor, T.;	Chief Engineer

MV RADIUM EXPRESS (Charter)

O'Sullivan, J.;	Master
Jensen, K.;	Chief Engineer

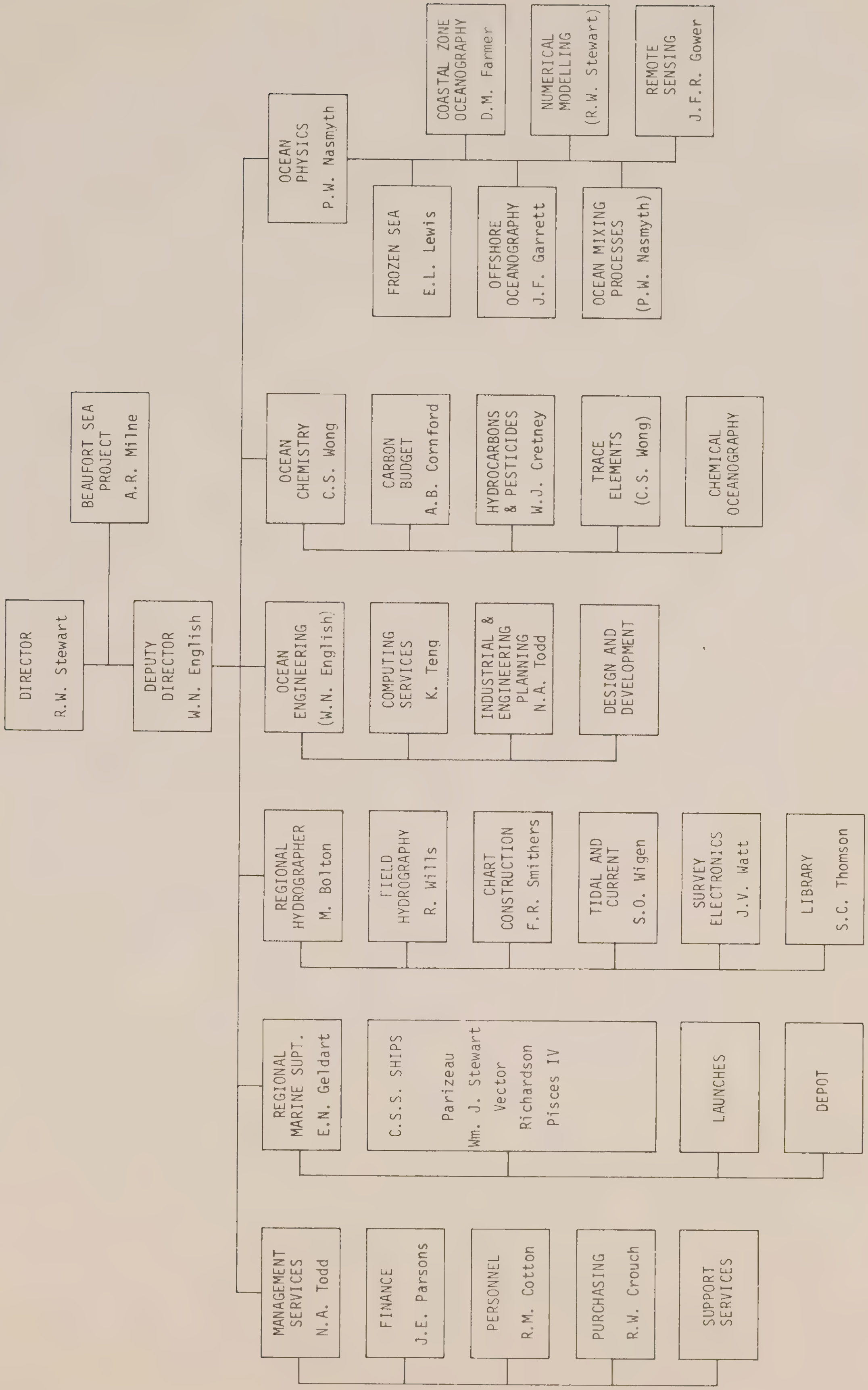
PISCES IV

Harrison, LCDR. D.;	Chief Pilot (DND)
Legallais, CPTN.P.S.;	Pilot (DND)

DEPOT SUPERVISOR

Dale-Johnson,V.L.E.	Master,350 T

* Left during 1973.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R.W. Stewart
BEAUFORT SEA PROJECT
A.R. Milne
DEPUTY DIRECTOR
W.N. English
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P.W. Nasmyth
COASTAL ZONE OCEANOGRAPHY
D.M. Farmer
NUMERICAL MODELLING
(R.W. Stewart)
REMOTE SENSING
J.F.R. Gower
FROZEN SEA
E.L. Lewis
OFFSHORE OCEANOGRAPHY
J.F. Garrett
OCEAN MIXING PROCESSES
(P.W. Nasmyth)
OCEAN CHEMISTRY
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M. Bolton
FIELD HYDROGRAPHY
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INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT – 1974

ENVIRONMENT CANADA

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

Please address all inquiries to:

Environment Canada
The Institute of Ocean Sciences
512 - 1230 Government Street
Victoria, B.C. V8W 1Y4
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INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

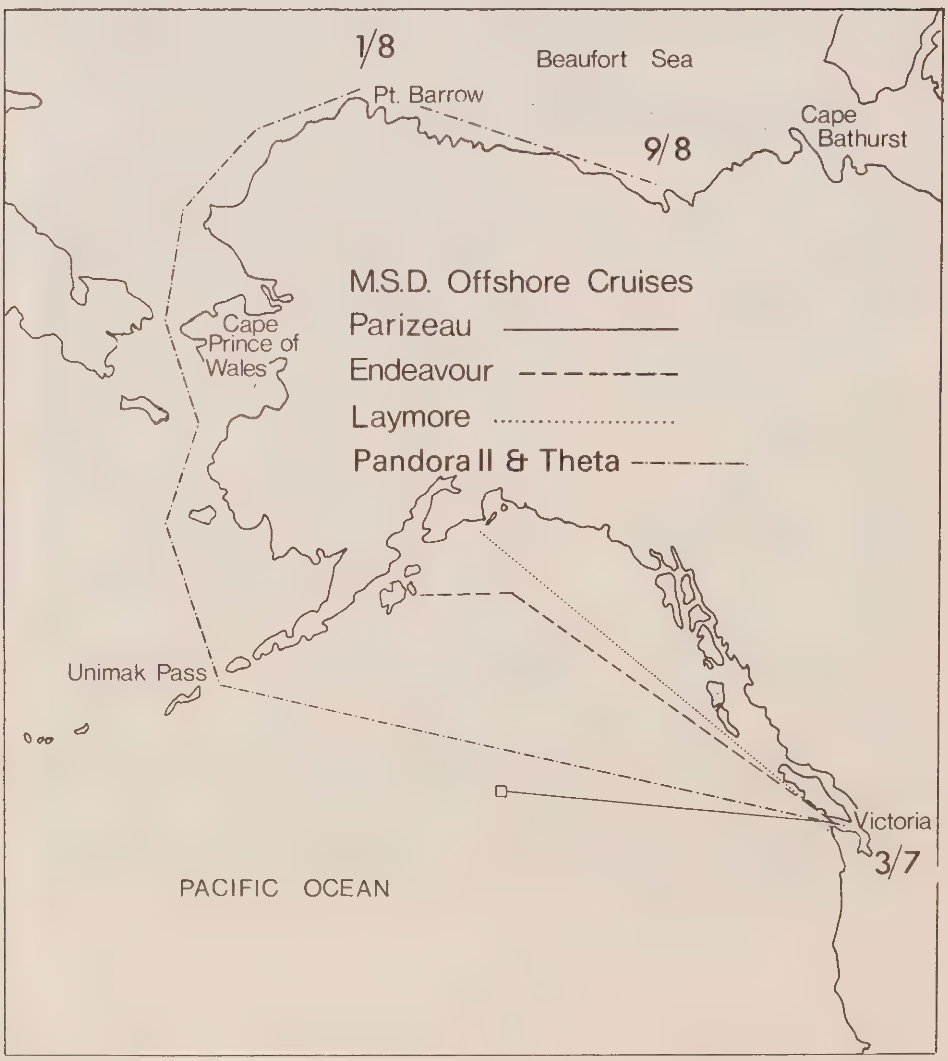
ANNUAL REPORT 1974

Patricia Bay Wharf, December, 1974

Victoria, B.C.

March, 1975

Contents



1/8
Beaufort Sea
Pt. Barrow
Cape Bathurst
9/8
M.S.D. Offshore Cruises
Parizeau
Endeavour
Laymore
Pandora II & Theta
Cape Prince of Wales
Unimak Pass
Victoria
3/7
PACIFIC OCEAN

Introduction

The activities of a government organization like ours seem in many ways to show an analogy with the weather. Although there is a basic 'climate',in which one recognizes that the summer is certainly different from the winter and Victoria is different from either Winnipeg or Honolulu, the day-to-day 'weather' varies so much that each year must be regarded as being extraordinary. During 1974 in our activities (as in the weather in many parts of the world) the year was more than usually extraordinary. Fortunately we did not experience any reorganization, although one looms for 1975. We did experience a name change, so that during 1974 we were officially the Pacific Region of Ocean and Aquatic Affairs, Fisheries and Marine Service. The new title is not widely admired either within or without our organization and hopefully it will be short-lived. One of the portentous events of 1974 was the fact that we were able to negotiate all of the remaining hurdles facing our new facility at Patricia Bay. Construction is now underway and, except for the personnel of the Ocean Physics group who are frequently assailed by the noise of heavy machinery, we all look with eager anticipation at the progress being made.

Returning to the subject of names, we propose to call our Patricia Bay establishment the Institute of Ocean Sciences. With its imaginative design - low, conforming to the terrain, and deliberately constructed to facilitate interdisciplinary communication - we hope to have an exciting facility in which to conduct exciting work. With the sea and our dock at one door and the airport and our hangar at the other we may be better placed for late 20th century ocean science than any other organization in the world.

Our programs were themselves extraordinary in 1974. It was the year of the GARP Atlantic Tropical Experiment. Canada's contribution to that Experiment, probably the greatest international cooperative experiment of any kind ever held, was the weathership Quadra and a complement of scientists drawn from all across the country. We were heavily involved in getting Quadra to sea for this operation, and gratified to find that Quadra's contribution was internationally recognized as being of absolutely prime importance. Mr. M. Bolton, the Regional Hydrographer, took full responsibility for readying the ship, together with its complex of equipment, for this operation. He also served as senior scientist for the first and perhaps the most difficult phase. Dr. W.N. English, Deputy Director-General, was senior scientist for the third and last phase, when Quadra was involved in complex operations both meteorologically and oceanographically.

With Quadra absent, the weathership station had to be filled by another vessel. We undertook this task with CSS Parizeau. Parizeau carried out this unfamiliar meteorological task, for which she was not designed, with great competence which was highly praised by the Atmospheric Environment Service.

The Parizeau being thus occupied we had to forego one year of hydrographic effort in the western Arctic. This was a serious blow to our ongoing survey program here. However it should not be thought that our overall Arctic concentration was reduced. Rather it was greatly increased because of the other extraordinary role that we had to play.The Beaufort Sea Project is being run from our offices - not only the very considerable activity carried out by our own personnel or by contractors under our supervision - but all other Beaufort Sea activities by groups scattered across the country, ranging from wildlife biologists to engineers trying to cope with oil spill technology.

The Beaufort Sea Project, whose manager is Mr. A.R. Milne, head of the Arctic Marine Section, is financed at a level of something over $4,000,000 by the oil industry and is contributed to by government in-house activities amounting to perhaps something over $7,000,000 for the two years of the project.

Our charter vessel MV Pandora II,mothership for our submersible Pisces IV,was no sooner put into commission than she was sent to the Beaufort Sea to take part in this project. She was accompanied by the charter vessel MV Theta. However the western Arctic experienced the worst ice conditions in many years and the amount which could be accomplished from these ships was much less than had been hoped and planned. As a result a great deal of innovative thinking had to be employed to try to get the work done using fixed wing aircraft and helicopters. A remarkable amount was accomplished, and if the 1975 ice year proves not to be too disastrous, we should come out of the experience quite well. Even now, it is evident that the work done in the Beaufort Sea Project, together with the consolidation of the results obtained by many groups over many years in the past, will present us with a level of understanding of this sea far beyond what we had before 1974. Nevertheless, it must be recognized by all that we shall remain at the end of 1975, in a far from satisfactory position of knowledge vis-a-vis potential development in the area, and much work will remain to be done after the completion of the project. We must expect that our future level of activity in this part of the world will be substantially greater than in the past.

Of course most of our usual activities continued, and they should not be underrated. Despite the absence of a Beaufort Sea hydrographic program, the Hydrographic Division was fully occupied with B.C. coastal waters and the Mackenzie River. The Ocean Physics Division was not only heavily involved in the Beaufort Sea but also in B.C. coastal waters. So also was the Ocean Chemistry Division. These ongoing activities are the backbone of our work. They provide the source of expertise which permits us to undertake the extraordinary when we are called upon at short notice to do so.

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

The hydrographic survey program in 1974 was influenced to a large extent by two external factors: The Beaufort Sea Project and the GARP Atlantic Tropical Experiment. Regional participation in these activities necessitated major changes in scheduled hydrographic programs. The electronic positioning system in the Western Arctic, operated by the Polar Continental Shelf Program, was located in the Beaufort Sea covering an area already charted, and the CSS Parizeau was withdrawn from normal survey duties as a replacement for CCGS Quadra on ocean station P from May through October.

Other effects of these unique programs included diverting some of the Tidal and Current Survey effort into the Beaufort Sea Project to provide essential baseline data on tides and currents. The Regional Hydrographer was directly involved with the planning of, and participation in, GATE to the extent of at least 50 percent of his time.

Much of the work in Chart Construction and Hydrographic Development was directed towards the metric conversion of navigational charts. Preliminary analyses of modes of conversion and of various chart formats were investigated.

Another major activity resulted from the decision to transfer to the region the responsibility for drafting and printing of West Coast navigational charts. This should result in a more effective flow of hydrographic data from the field hydrographer to the user through faster production of new nautical charts.

A hydrographic survey station 4300 feet above sea level. Here a tellurometer measurement is being made to the geodetic station 'Robinson' as part of a control survey in Seymour Inlet.

Field Hydrography Section

R. Wills - Regional Field Superintendent

I.J. Campbell	* C.G. McIntosh
* E.B. Clarke	A.R. Mortimer
F.A. Coldham	A.D. O'Connor
K.L. Czotter	R.A. Pierce
G.H. Eaton	R.D. Popejoy
N.S. Fujino	A.R. Raymond
K.A. Gantzer (from Coastal Zone Oceanography)	G.E. Richardson
* K. Highton	* G.W. Rogers
R.C. Hlina	R.W. Sandilands
L.P. Landry (to Coastal Zone Oceanography	C.R. Tamasi
J.B. Larkin	* J.A. Vosburgh
* P.O. Lee	M.V. Woods
B.M. Lusk	* P.Y. Yee
	B. Aitken (student assistant)
	P. Thompson (student assistant)

* Left during 1974

This Section is responsible for all hydrographic field operations and includes Sailing Directions and Hydrographic Development.

No hydrographic work was done in the Western Arctic this season, primarily because CSS Parizeau was not available. Consequently a greater than normal effort was made on the B.C. coast.

A highly detailed, large-scale survey of the Fraser River delta front, both before and after freshet, was carried out in cooperation with a geological survey team from EMR and is expected to yield valuable information in the field of delta studies. The survey party, under the direction of A.R. Mortimer, employed a variety of small craft and precise positioning systems.

Victoria Harbour and an area off Race Rocks, unsurveyed since leadline days,were also recharted.

Revisory surveys, with B.M. Lusk as hydrographer-in-charge, employed CSS Richardson, CSS Revisor and a variety of smaller craft to cover the entire southern B.C. coast. More than 150 low-altitude aerial photos taken from a chartered Beaver aircraft provided essential data to define changes that have taken place over the years. This party also completed large-scale conventional surveys of Fisherman's Cove, Whiterock Passage, Cortez Bay and Vananda Cove.

Geodetic control was extended from the mountain peaks to the shoreline in Seymour and Belize Inlets, an important and long-deferred project. A chartered Bell Jet Ranger helicopter was employed.

Major survey work was carried out by the CSS Wm.J.Stewart, under the direction of R.W. Sandilands, in Malaspina Strait extending up Jervis Inlet

and including Hotham Sound and Agamemnon Channel, in Barkley Sound, and in the Skeena River and approaches. Barkley Sound was last surveyed in the 1920s and the Skeena River in 1909-1914. Major changes were found, as expected, in some of the Skeena River banks. During this project Dr. John Lutenauer of Geological Survey, Vancouver, was on board for a week to carry out sediment investigations. One launch and one hydrographer were assigned to him for this period.

Barkley Sound is a continuing project and good progress was made in Trevor and Imperial Eagle Channels. The CSS Wm.J.Stewart party converted all data collections to metric this year and will be conducting all future surveys in metric units. This completes the conversion process and all hydrographic field operations, with the exception of revisory surveys, will be metric.

Valuable revisory and new survey work was continued on the Mackenzie River, employing the chartered vessel MV Radium Express with A.D. O'Connor in charge. Surveys were completed to provide data for five new charts and a large portion of Mackenzie Bay was surveyed for the first time. Certain areas of the Mackenzie River were resurveyed as part of a program in which selected areas are resurveyed each year to determine how the river bed changes from year to year. A short reconnaissance was made up the Liard River, by ship and launch to the 'Beaver Dam', and beyond by aircraft.

Charter vessel MV Radium Express
at Mile 464, Mackenzie River.

HYDROGRAPHIC DEVELOPMENT

N.M. Anderson - Head

† G.W. Rogers
A.R. Raymond

M. Lee (summer student)
†† L. McLeod
†† M. McIntyre

† Rotational staff
†† Term assignments

Aerial Hydrography Project

J.V. Watt and D.V. Gregson returned to Victoria in September after an 18-month secondment to the Canada Centre for Remote Sensing (CCRS) in Ottawa working on this project. The objective is to develop an airborne surveying system for coastal hydrography which will define both shoreline and depths of up to 10 metres. The aircraft installation consists of an inertial navigation platform, an aerial camera, a barometric altimeter and a magnetic tape data logging system.

Flight tests were conducted in June and in August over a test range near Ottawa and over the National Research Council photogrammetric test range near Sudbury, Ontario. Analysis of the data is underway to determine if the positional and rotational parameters are sufficiently accurate. The analysis is being conducted jointly by IOS and the University of New Brunswick. A detailed status report by J.V. Watt was submitted to the CCRS management committee in September.

The second stage of this mapping system is the measurement of the hydrographic parameters on the aerial photographs using an analytical plotter. A second set of photographs (flown by CCRS) with horizontal control provided by IOS has been sent to UNB for further evaluation of the numerical model used to correct for refraction at the air/water interface.

Metrication

Over the next few years approximately two hundred west coast charts are to be converted to metric units. A thorough analysis of alternative automated processes for conversion is being conducted. New chart formats are being investigated in cooperation with Chart Construction Section.

Range/Accuracy Evaluations

Range/accuracy evaluations of short-range positioning systems have been limited to 21.5 km. Baselines have now been established to extend the evaluations at 10 km intervals to 100 km and for more detailed short-range evaluations at 100 m intervals to 1.2 km. Mini-ranger, Trisponder and RPS positioning systems are all presently being checked on this test range.

SAILING DIRECTIONS

T.L. Jones - Head

J.W. Chivas L.M. Wakefield

The preparation of new editions of the Unit's publications was complicated by 'teething' problems encountered in the coding and keyboarding processes in Ottawa.

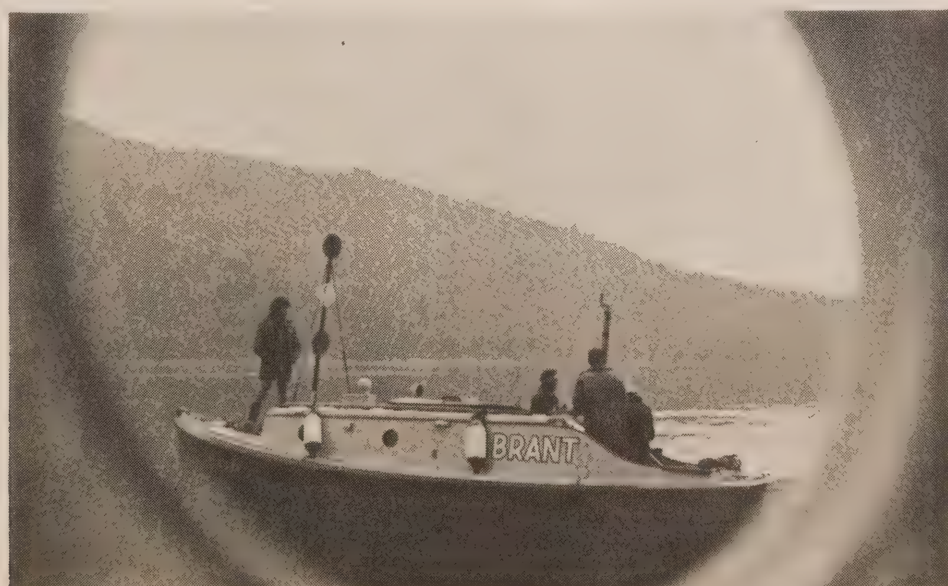
The ninth edition of B.C. Sailing Directions, Volume 1, was published in October with an increase in size from 344 to 401 pages.

The manuscript of Volume 2 of the B.C. Sailing Directions was finished and proofreading and correction of printouts and blueprints were completed. The book will be published in the new format early in 1975.

The second edition of the Small Craft Guide, Volume 1, which proved very popular with the recreational boating community, was updated and published in December.

In the spring of 1974 J.W. Chivas undertook a survey of the coast from Boundary Bay to, and including, Howe Sound to collect material for the second volume of the Small Craft Guide. This publication is designed to provide navigational and other useful information for the increasing number of small-craft owners travelling along the east side of the Strait of Georgia between Boundary Bay and Cortez Island. The Guide also covers the Fraser River to Coquitlam, the Pitt River and Pitt Lake. The first draft of this publication is now complete, and publication is scheduled for mid-1975.

Kootenay Lake and River Sailing Directions were revised, adding material gathered in 1973. These have been submitted for publication with the revised charts of the area.



Hydrographic launch leaves
CSS William J.Stewart during Jervis Inlet Survey

Tidal and Current Survey Section

S.O. Wigen - Regional Tidal Superintendent

During 1974 the Section conducted major field programs in both the Pacific and Western Arctic. Hydrodynamic surveys continued in Juan de Fuca, Haro and Rosario Straits. Tide and storm surge propagation were monitored as part of the Beaufort Sea Project. Vertical control was provided for Mackenzie River charting. Gauging stations were moored on seamounts of the northeast Pacific as part of the GEOS-C satellite program.

HYDRAULIC RESEARCH

A.B. Ages - In Charge
K.S. Lee (CELL)
A.L. Woollard (Computing Services)

This Unit continued developing a two-dimensional numerical model of Burrard Inlet to study and predict tidal currents in the inlet including English Bay, Vancouver Harbour, Port Moody and Indian Arm.

A detailed analysis of a previously developed numerical model of the Fraser River was carried out.

Advice was provided to government agencies and private industry on various problems concerning tidal hydraulics and marine pollution.

Improvements were made to oil spill markers designed to locate a spill in fog and darkness when visual reconnaissance is not possible. The Unit continued testing a method to establish reference levels across estuaries.

CURRENT SURVEYS

J.F. Bath (deceased)
A.N. Douglas (Computing Services)
W.J. Harris
F.V. Hermiston
W.S. Huggett - In Charge
* T. McNie
M.J. Woodward

* Left in 1974

From February to April a cooperative current survey was carried out with National Ocean Survey (NOS) of Seattle in the vicinity of the San Juan Islands. Data from this survey have been edited and preliminary analyses of the data are being prepared for publication in the form of histograms of velocity and direction, hourly plots of velocity, direction, progressive vector diagrams and energy spectra diagrams, and (where available) temperature and conductivity. Data are exchanged on a continuing basis with NOS in Washington, D.C. A four-day attempt with a submersible to retrieve four lost current

meters was unsuccessful. Further attempts will be made.

The main effort of this Unit was directed towards deploying ten current meter and tide gauge arrays in May in the Beaufort Sea and retrieving them again in August. These were successfully anchored through holes blasted in the ice.

Transport of instruments was done by helicopter. Since arrays were laid up to 70 miles offshore, Decca 6F was used for a positioning system. Due to heavy ice conditions only one current meter and two tide gauges were retrieved. Data from these three instruments are being analysed. All moored instruments are capable of one year unserviced operation and recovery of the remainder will be attempted in 1975.

Two current meter arrays of two and three current meters respectively, each with one tide gauge, were laid off the west coast of Vancouver Island. This work is being carried out in cooperation with Dr. A. Huyer of Ottawa, and is concurrent with similar arrays being laid off Washington and Oregon to study the coherence of circulation along the coast.

The vector average of two eight-month analyses of Race Rocks current observations was completed and current predictions for a position four miles south of Race Rocks will be inserted in the 1977 tide tables. Printed copies of predictions for 1975 and 1976 will be available from this office in due course.

TIDAL SURVEY

R.E. Brown	J.D. Scott (CELL)
W.J. Rapatz - In Charge	F.E. Stephenson

A number of temporary tidal stations were operated on the west coast. Data from these stations are used in the numerical model of Juan de Fuca and Georgia Straits.

The important tidal station on Langara Island at the Northern end of the Queen Charlottes is now fully operational. The station records on site, as well as transmitting instantaneous water levels to a monitoring station at Prince Rupert tied into the Pacific Tsunami Warning Network.

A tidal seamount program was initiated in May. Between May and November, five Aanderaa tide gauges and one UBC tide gauge were placed on five seamounts off the continental shelf (Cobb, Union, Bowie, Patton and Surveyor). Recovery of gauges will be attempted in February and April 1975. Two Aanderaa tide gauges are being used to measure the tide on the inside and outside of the breakwater at Neah Bay, Washington. The results of this study will determine the

validity of using tidal data obtained from inside the breakwater as input to the numerical model of the Straits of Georgia and Juan de Fuca.

In conjunction with a study of storm surges in the Beaufort Sea, six tide gauges were installed for the summer along the coast between Herschel Island and Baillie Islands. The tide gauge installed at Herschel Island in September 1973 was recovered and the tapes and batteries changed. The instrument was reinstalled and will record unattended until recovery next summer.

On the Mackenzie River, water level gauges were installed at miles 423, 464 and 934 to provide datum control for hydrographic charting.

An extensive up-dating of secondary ports tidal differences for the southern half of the B.C. coast was carried out and will appear in the 1976 tide tables.

Improved tables for the prediction of water levels on the Fraser River as far east as New Westminster were published through Notice to Mariners and will also appear in the 1976 tide tables.

The Tidal Unit spends much time each year providing information to the public, and to engineering firms and port authorities regarding water levels and datum planes on the Pacific coast and in the Western Arctic.

DATA PROCESSING

S.E. Ames - In Charge
C.C. Carracedo
M. Lee
D.E. Hilder (Digitizing by
L. Ponce contract)
E. Stenning (Diagram checking by contract)

* Left in 1974

The Unit processed the tidal records from all temporary stations established by tidal survey or hydrographic field parties. In September the processing of records from all west coast permanent stations operated by Water Survey of Canada was begun.

Work was completed on new analytic programs to streamline processing of records and eliminate the need for outside computer facilities. Data to be retained or forwarded to Ottawa will now be placed on magnetic tape rather than punched cards.

Chart Construction Section

F.R. Smithers - Regional Chart Superintendent

This Section is responsible for the construction, publication, revision, correction and distribution of all nautical charts and publications to 180 authorized chart dealers. Graphic arts for exhibits, illustrations for seminars and regional publications, as well as all photographic and printing services, are provided by the Section.

CHART CONSTRUCTION

R.D. Bell - Supervisor

T.C. Plume	R.K. Korhonen
M.S. Taylor	C.J. Nast (Photographer)
V.N. Young	B.M. Watt (Graphic Arts)

CHART REVISION

K.R. Holman - Supervisor

A.G. Lyon	P.C. Browning
A.R. Philp	

QUALITY CONTROL

L.G. Thompson - Supervisor

D.G. Dobson

There were seven first editions of new charts compiled and drafted in 1974:

3060	Pitt River	
3985	Approaches to Prince Rupert Harbour	(converted to provisional printing)
3989	Brown Passage	" " " "
3991	Hudson Bay Passage	" " " "
3992	Approaches to Portland Inlet	" " " "
3993	Work Channel	" " " "
3481	Approaches to Vancouver Harbour	(metric conversion)

Six new editions were published as a result of recent hydrographic surveys and 50 patches were drawn and published to update other charts. Ten notices to shipping and 60 notices to mariners were promulgated. The marine reporting program with the Canadian Power Boat Squadrons was very active this year with 210 reports received and actioned by the revisory survey group.

Methods of conversion of charts from English to metric units have been under active investigation. One conversion, Chart 3481 (Approaches to Vancouver Harbour), which depicts a new format in addition to metric units, will be published in full colour in January 1975.

CHART CORRECTION AND DISTRIBUTION

E.M. Coulter - Supervisor, Chart Correction

K.M. Bennett
D.J. Clark
R.W. Johnson
M.M. Patton

J.H. Coldwell - Supervisor, Chart Distribution

L.M. Wakefield
J. Brown (CELL)
J. Lang (CELL)
J. Underwood (CELL)

This Unit made 2,061,470 hand amendments and distributed 168,200 nautical charts to dealers and the marine public. They were also responsible for the distribution of 55,134 Tide Tables, 3,279 B.C. Pilots, 966 Light Lists and 381 Radio Aids. The inspection of facilities and stock of 40 authorized dealers was made, resulting in the cancellation of 13 dealerships. During the year, 30 new chart dealers were authorized.

The Chart Construction Unit built and staffed a nautical chart display for the Vancouver Boat Show. The display featured the automated acquisition of hydrographic field data. The simulated acquisition system was mounted in a survey launch which was floated in the Agradome building, flooded for the show.

Shopping centre displays included three weeks at Surrey, two weeks at Park Royal, West Vancouver and two weeks at Hillside, Victoria.

More than two million charts were amended by hand during 1974.

Survey Electronics Section

J.V. Watt - Head

The return of the Head of Survey Electronics from CCRS, Ottawa, coupled with a strengthening and reorganization of the Section has developed a more efficient service and research function. The rotation of electronic technicians between maintenance and development projects is providing greater flexibility and expertise in engineering, electronic and technical support for all Divisions.

During 1974 the Section was restructured into two groups: Technical Support and Engineering Support. The Technical Support Group has been subdivided into three units, each having specific equipment responsibilities (digital and sounder, communications, navigation aids and microwave). The technical personnel are to be rotated on a regular basis through these units and through design/development positions within the Engineering Support Group.

The Ottawa-based support to the Aerial Hydrography Project (see Hydrographic Development) has been completed. Future activities will be conducted in the Victoria area by the Engineering Support Group.

TECHNICAL SUPPORT GROUP

W.R. Taylor - Head

* G.L. Cooke	* A.W. Koppel
R.A. Cooke (with FSRG)	R. Loschiavo
L.W. Dorosh	R.A. Muse
* T. Dyas	M. Osborne
E.W. Hinds	C.F. Ryan
	D.J. Gregson

* Left during 1974

Activities of the Technical Support Group involved field support for survey parties on board the CSS Wm.J.Stewart and MV Radium Express in addition to general electronic maintenance duties for Hydrographic and Ship Divisions.

The program to update and convert ships' communication equipment resulted in the acquisition and installation of single side band HF radiotelephones and upgrading of VLF communications on all major vessels.

A new VHF analyser/communications monitor was acquired. It provides increased capability and greatly simplifies testing and servicing of VHF equipment. Routine maintenance checks such as frequency and deviation can now be carried out from the lab with the radio equipment still on board ship, from a range of several miles if necessary.

Electronic positioning system specifications were modified for Field Hydrography and a contract was let for the supply of two positioning systems (microwave, range-range type).

ENGINEERING SUPPORT GROUP

T.A. Curran J.L. Galloway

The Engineering Support Group provided assistance to the Hydrographic, Ocean Physics and Ocean Chemistry Division.

Specific support for Field Hydrography concentrated on automated field data acquisition systems. Development proceeded on one system utilizing a micro-processor. Specifications have been developed and a requisition issued for a prototype unit which will be light-weight, accurate and inexpensive.

For the Tidal and Current Section modifications to a UBC-developed underwater tide gauge were carried out, resulting in high resolution water temperature recording and deeper water operations to 1000 metres. Data from these gauges have been analysed using numerical filtering and spectral analysis techniques in order to evaluate instrument performance.

A prototype solid state design to replace the relays in the Neyrpic current meter was developed. A turntable was designed and built to enable the rapid calibration of current meter compass errors.

Activities supporting Ocean Physics Division included the design and interface of a Memodyne tape reader to the HP computer for Coastal Zone Oceanography. A reader for Geodyne current meter tapes was designed and is being interfaced with the HP computer for Offshore Oceanography. A temperature depth probe (ETB) was modified to allow operation by hand or from a small winch, and a camera timer was constructed for a radar experiment, both for Coastal Zone Oceanography.

Support to Ocean Chemistry included the interfacing of two IR analyser-printer systems for laboratory and shipboard pCO_2 experiments, and the design and construction of a NIM module as part of the tritium experiment.

A complex system of communicating in serial ASC 11 using Serdex models is undergoing tests with an objective of interfacing much of the laboratory equipment with the PDP-11 computer system.

A general program for the calibration of all electronic test equipment on a regular basis was instituted, utilizing the facilities at the Dockyard (DND) Calibration Centre.

OCEAN CHEMISTRY DIVISION

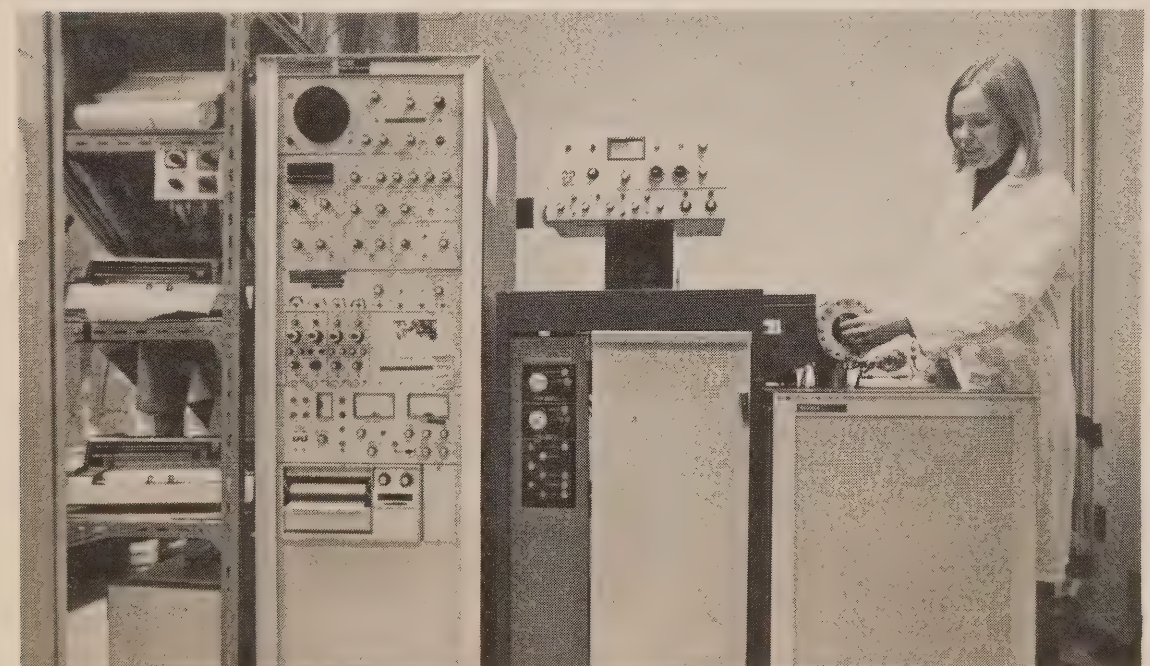
C.S. Wong - Chief of Division

Marine Hydrocarbons Section

W.J. Cretney - Head

P.A. Christensen (NRC Postdoctoral Fellow) - *GC/MS system*
B.J. Cox (CELL)
W.J. Cretney - *Hydrocarbon analysis*
D.R. Green (Visiting student,UBC) - *Pelagic tar*
K.W. Johnson
R.W. Macdonald (NRC Postdoctoral Fellow - *LMW Hydrocarbon gases*
B.W. McIntyre (CHEMEX Lab)
C.S. Wong - *Environmental effects*

This Section studies the occurrence, pathways and fate of hydrocarbons (natural, petroleum-based and halogenated) in the marine environment. The major part of the work has been to study petroleum-based hydrocarbons in order to assess the possible environmental effects of oil spills and offshore drilling. At present there is a critical lack of knowledge of the levels of hydrocarbons (usually very low) in sea water, sediments, the biota and the atmosphere, and of the sub-lethal effects of these low concentrations.



A Finnigan 3300E gas chromatograph/mass spectrometer system is used for hydrocarbons detection and identification in marine environmental samples.

Much effort has been devoted to shore-based and shipboard facilities so that total hydrocarbons at a low concentration (1 ug/l. to 1 ng/l.) in sea water can be determined, and certain environmentally significant compounds can be identified by instrumental techniques. A portable clean laboratory for shipboard hydrocarbon analysis can be conveniently fitted on the three Pacific Region ships, CSS Parizeau, CSS Vector and MV Pandora II (charter).

A Finnigan 3300E gas chromatograph/mass spectrometer (GC/MS) system capable of a mass range of 10-1000 amu and a sensitivity of 3×10^{-11} g/sec for cholesterol was acquired to ensure more reliable identification and more sensitive detection of polyaromatic compounds in marine environmental samples. A technique using fluorescence in combination with a high speed liquid chromatograph (FS-HPLC) was being applied to monitor total polyaromatic hydrocarbons at ocean weather station P, along line P in Saanich Inlet and nearshore waters in Victoria. Clean laboratory extraction techniques of polyaromatic hydrocarbons from biological tissues and marine sediments are being developed.

A tar map has been prepared using data of Neuston-net tows of the Canadian TRANSPAC-72 cruise, the TASADAY cruise of Scripps Institution of Oceanography and other Scripps Neuston-net collections, along with data from recent Japanese publications. Findings show heavy concentrations of pelagic tar in the Kuroshio current off eastern Asia and Japan, while the waters in the north and eastern Pacific are relatively clean. The distribution apparently is related to marine oil transport routes.

Beaufort Sea Baseline Studies

Project C-1: Distribution of tar and other particulate pollutants along the Beaufort Sea coast.

C.S. Wong - *Chief Investigator* D.M. Macdonald (CELL)
R.D. Bellegay - *Co-Investigator*

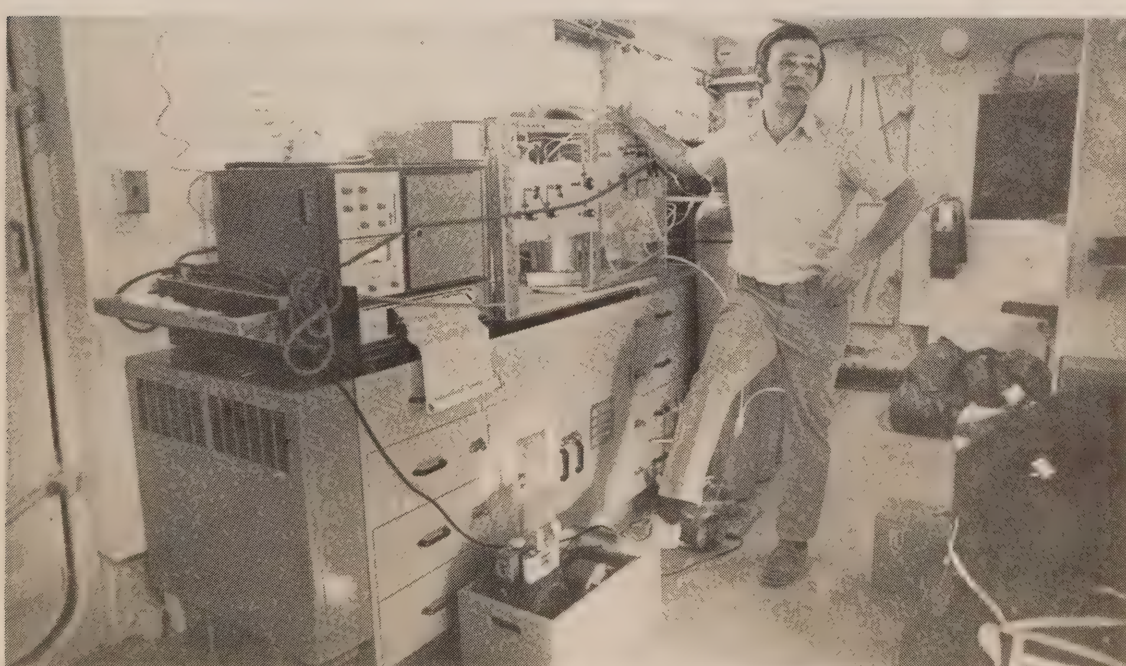
This project hopes to establish the baseline distribution of particulate pollutants, especially tar and plastics, in the present-day Beaufort Sea marine environment. A search for areas with natural oil seepage has been made both in the field work and in available geological literature. A coastal survey was conducted in the summer of 1974 on contract to CELL to cover the southwest coast of Mackenzie Bay and portions of the west coast of Tuktoyaktuk Peninsula. No visual tar pollution or natural seepage were found, but plastic wastes, in particular those related to marine seismic activities, were prevalent in the coastal areas. Beach and near-shore sediments, marine organisms and fish were collected and analyses are being made to establish their hydrocarbon characteristics.

Project C-3: Baseline information on chemical oceanography and petroleum-based hydrocarbons in the southern Beaufort Sea.

C.S. Wong - *Chief Investigator*
W.J. Cretney - *Co-investigator*
P.A. Christensen (NRC Postdoctoral Fellow) - *GC/MS studies*
P. Erickson (CELL)
B.L. Hubbard (Seakem)
B.W. McIntyre (CHEMEX Lab)
R.W. Macdonald (NRC Postdoctoral Fellow) - *LMW hydrocarbons*
S. Seehan (Summer student)

Objectives of this project are to (1) provide a comprehensive understanding of the chemical oceanography of the area and (2) to establish the baseline levels of petroleum-based hydrocarbons in the southern Beaufort Sea drilling area, by measuring classes of hydrocarbons and identifying some specific hydrocarbons in sea water, marine sediments, marine organisms, marine mammals and fish.

A preliminary cruise on the MV Theta was manned in August of 1974. The preliminary data show a clean marine environment. No tar or plastics were collected in Neuston-net tows. The levels of dissolved polyaromatic hydrocarbons in sea water are similar to those in uncontaminated open ocean waters in the Pacific Ocean. The levels of dissolved gaseous hydrocarbons, including methane, ethane and propane, plus olefins, are low in general.



Gas chromatograph and helium stripping technique was used on board MV Theta to detect low molecular weight hydrocarbons in the Beaufort Sea.

Marine Carbon Budget Section

A.B. Cornford - Head

A.B. Cornford - *Radiocarbon, ^{13}C isotopic studies*
C.S. Wong - *Inorganic carbon system, air-sea CO_2 exchange*

K.S. Rennie (CELL)
P.A. Zellinsky (CELL)
R.D. Bellegay

Concern regarding the possible climatic effects of CO_2 released into the atmosphere by burning of fossil carbon requires a close surveillance of the natural CO_2 system. The input of CO_2 from fossil fuel burning has been doubling every twenty years. However, the continuous exchange of CO_2 in the atmosphere-ocean system and to a lesser extent, the biosphere, has kept the atmospheric CO_2 increase at a slower rate than the input. The carbonate chemistry of the surface ocean is playing a vital part in the CO_2 equilibration process in this global atmosphere-ocean system.

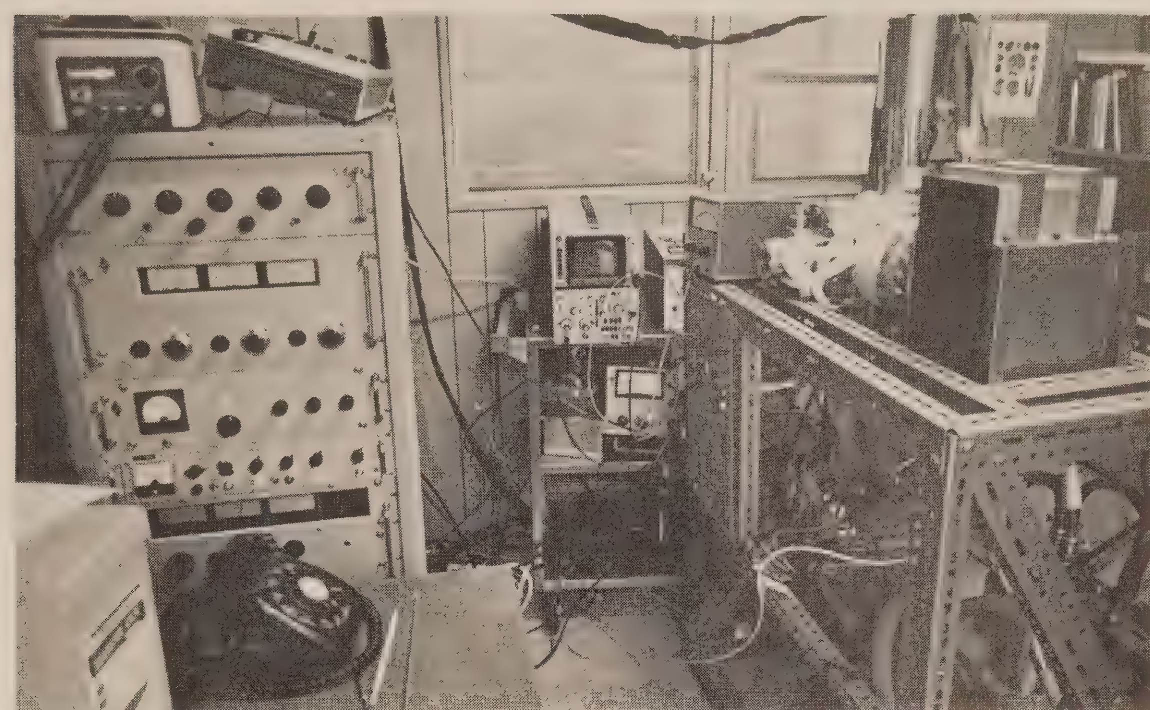
Research work on the CO_2 problem has been focussed on long-term time series studies of CO_2 exchange in the atmosphere-ocean system, in particular at ocean weather station P (50°N, 145°W), which is the only fully marine CO_2 station in the world. Three aspects are being studied: (1) marine air CO_2 increase, (2) air-sea CO_2 exchange and carbonate chemistry in the surface sea water, and (3) radiocarbon study of CO_2 exchange rate.

The radiocarbon laboratory set up by contract is now in operation at B.C. Research in Vancouver. An intercalibration with the radiocarbon laboratories at the University of Washington (Dr.Stuiver) and the University of Miami (Dr.Ostlünd) has been completed. Station P surface sea water samples, collected in previous years, are being processed and counted. An AEI MS20 isotope mass spectrometer has also been set up in the Ocean Chemistry laboratory at Harbour Road, for $^{13}C/^{12}C$ analysis. The $^{13}C/^{12}C$ ratio is required to eliminate differences introduced by isotopic fractionation in radiocarbon samples. It is also needed for a tracer study in the Saanich Inlet waters.

The invasion and evasion of CO_2 in the surface mixed layer are being investigated by time-series studies of pCO_2 in air and surface sea water and of the carbonate chemistry at ocean weather station P. In order to study large-scale oceanic variations, the pCO_2 and carbonate chemistry programs were also carried out on the CCGS Quadra on her passages to and from Dakar, Senegal, using an automated measuring system for shipboard pCO_2 and air CO_2. A PDP-11 computer was used for data logging. A similar system without computer has been in use on the other weathership, CCGS Vancouver, for the time-series studies at station P.

Marine air CO_2 increase has been monitored for the sixth year in a DOE-Scripps Institution of Oceanography joint collection program at ocean weather station P. Our infrared CO_2 laboratory is carrying out air CO_2 analysis of flask samples being collected at other Canadian CO_2 stations manned by the Atmospheric Environment Service. To ensure the compatibility of monitoring results,a series of intercalibrations has been carried

out. There has been a continuing exchange of air samples from CO_2 analysis between the Division and Professor Keeling's group at Scripps Institution of Oceanography, along with exchange of standards tanks with the same group. Dr. Pearman (Applied Physics Laboratory at Asphendale, Australia) has been carrying out performance comparison of different infrared CO_2 analytical laboratories using a set of reference standard gases.



New instrumentation to detect lead in the marine environment combines a Nuclide thermo-ionic source with a quadrupole mass spectrometer.

Trace Metals Section

(C.S. Wong - Head)

C.S. Wong - *Lead, mercury in sea water*
P. Berrang (Visiting student, UVic) - *Lead methodology and mass spectrometry*
J. Piuze (NRC Postdoctoral Fellow) - *Anodic stripping technique*
K.W. Johnson

The main objective of the Section is to assess the natural and anthropogenic inputs of physiologically significant metals into the marine environment, with special reference to coastal and open ocean waters. As in the case of ultra-trace hydrocarbon analysis, trace metals studies require dedicated clean laboratories to seal off airborne contaminants, in particular lead aerosols. Such a clean shore laboratory is in full operation now and a shipboard portable clean laboratory is being set up.

Lead is an element of great physiological significance and it is extremely difficult to determine at the trace level due to atmospheric dust and lead aerosols. Analytical techniques have been receiving much attention in this program.

A flameless atomic absorptiometric method with a fast digital recording system, set up in a special clean laboratory, has been in use regularly in our trace metals studies. This technique was used in our IDOE-intercalibration on lead in sea water with Dr. C.C. Patterson's group at California Institute of Technology, and the total analytical blank in our clean laboratory was among the best.

To utilize lead isotopes as a tracer, Mr.P. Berrang has been developing new instrumentation by mating a Nuclide thermo-ionic source to a quadrupole mass spectrometer in a cooperative Ph.D. program between our Division and the Chemistry Department at UVic. Dr. Piuze has been developing the anodic stripping voltmatric technique for rapid analysis of sea water for lead, cadmium, copper and zinc.

Mercury in sea water in Saanich Inlet and at ocean weather station P is being studied by an ultraviolet spectrometric method, which was intercalibrated in June, 1974 with Dr. M. Bothner who originated this technique at the Oceanography Department, University of Washington. Good agreement was obtained and its application indicated mercury occurrence at 0.01-0.05 ppb. levels in marine waters.

Chemical Monitoring Program at Station P

R.D. Bellegay - *Coordinator of chemical program*
C.M. Jackson
K.W. Johnson
P. Munro
F. McLaughlin (CELL)
B. Cox (CELL)

Long-term trends of chemical parameters at ocean weather station P (50°N, 145°W) were monitored as a continuing effort of the Division.

Neuston-net tows were made between Victoria and station P to collect tar balls and other surface pollutants; samples of total dissolved aromatic hydrocarbons in surface waters were also collected; weekly samples of atmospheric CO_2, surface alkalinity, total CO_2 and surface radiocarbon were taken; continuous shipboard infrared measurements of marine air CO_2 and pCO_2 were made on a quarter-yearly basis; samples of nutrients were taken daily at station P to provide information about long-term fluctuations in relation to circulation and the marine food chain. The weathership program also included collection of tritium samples and measurement of mercury in sea water.

Chemical Studies in CEPEX

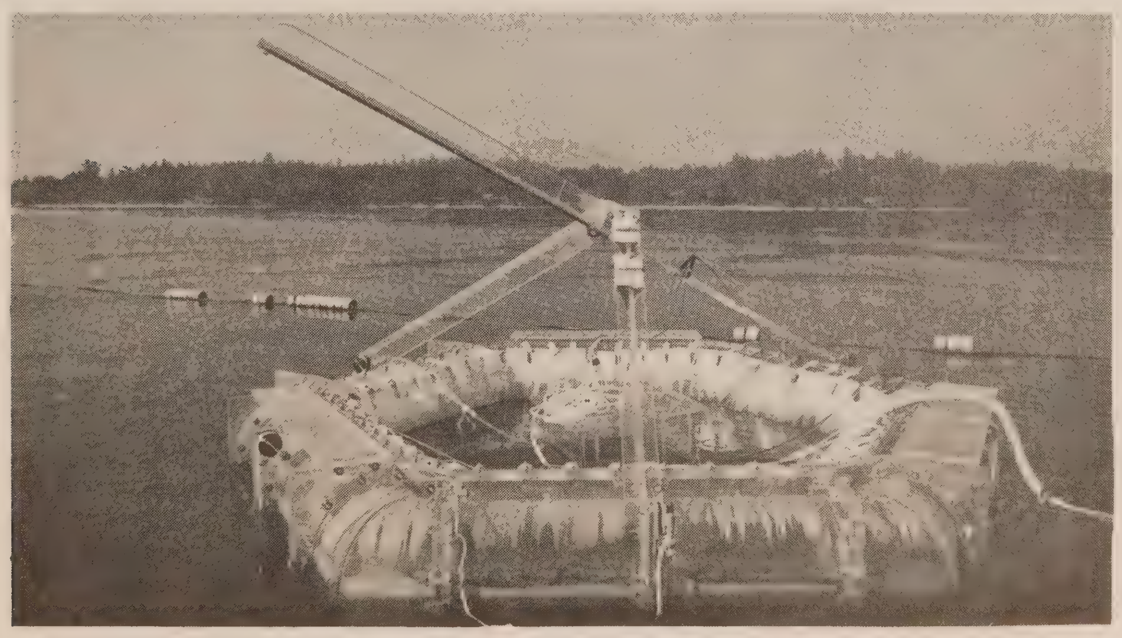
C.S. Wong - *Chief Investigator*
A.B. Cornford - *Carbon isotopes*
R.D. Bellegay
C.M. Jackson
P. Munro
K.W. Johnson
C.G. Morgan (Computer Services)
R. Rennie (CELL)

The Controlled Ecosystem Pollution Experiment (CEPEX) is an international cooperative program to study the effect of pollutants on mixed trophic levels of pelagic marine organisms, using large enclosures of natural sea water in Saanich Inlet. Two experiments have been performed by Ocean Chemistry Division.

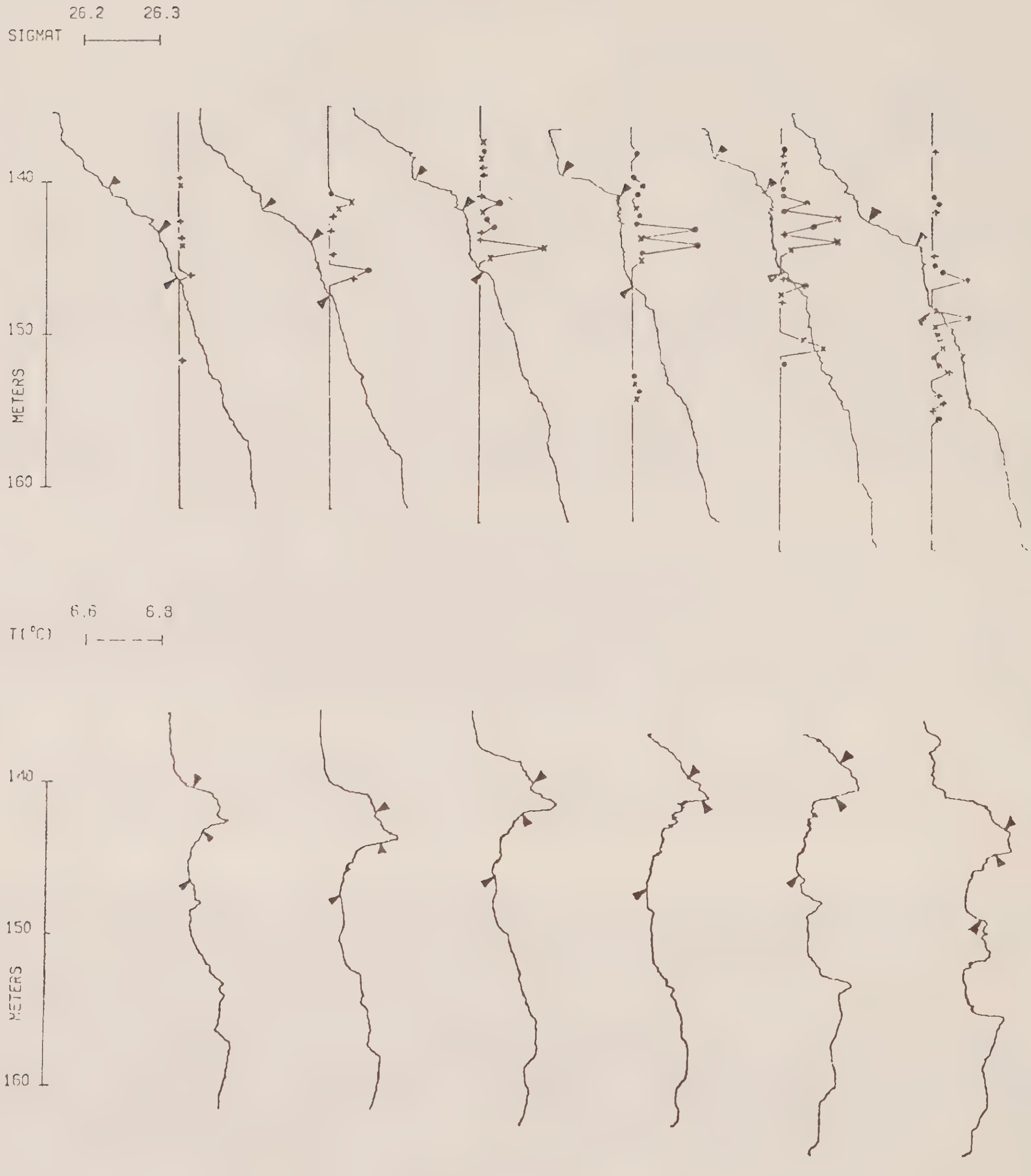
A dye diffusion experiment was carried out in April to investigate the rate of dispersal of water released from the enclosures. The Division worked in cooperation with Dr. M. Takahashi of the CEPEX Laboratory in Sidney.

During a copper pollutant experiment in May (manned by other groups) sea water samples were collected for analysis for $^{13}C/^{12}C$ ratio in preparation for the second experiment. During September and October two enclosures were used for a pCO_2 experiment. One contained natural sea water while the other was poisoned with copper.

Radiocarbon solution was also added and sampled later to determine its distribution in water and in marine organisms. Results are being processed in preparation for full-scale participation in further experiments in 1975/76.



Ocean Chemistry Division used large enclosures of sea water to study the effect of biological uptake on the CO_2 system as part of the Controlled Ecosystem Pollution Experiment (CEPEX) in Saanich Inlet.



Superimposed upon successive vertical profiles of density (σ_t) are the corresponding profiles of a derived quantity which may be interpreted as an intensity of turbulent mixing, plotted to an arbitrary scale. The vertical locations of three isopycnal surfaces are indicated by arrows on each density profile, and on each of the corresponding temperature profiles shown below. Most of the mixing in these profiles seems to occur in shear layers above and below a 'tongue' of warmer water which intrudes between the two upper isopycnals.

OCEAN PHYSICS DIVISION

P.W. Nasmyth - Chief of Division

The Ocean Physics Division has again increased slightly to a total of 41 permanent scientific and technical personnel, of which 19 are professional scientists. Further consolidation of the Division has taken place at the Patricia Bay site of the new Institute of Ocean Sciences. The only major component of the Division not yet located at Pat Bay is the Frozen Sea Research Group which cannot be properly accommodated until the Institute is completed. Three or four other stragglers remain on special assignments in downtown Victoria and in Vancouver.

Over the past year increased emphasis has been placed on the physical oceanography of the Arctic and B.C. coastal waters responding primarily to demands for a data base on which to assess the environmental effects of industrial development. It is anticipated that these trends will continue and intensify in the foreseeable future.

Activities of each Section are reported in the following pages.

Coastal Zone Oceanography Section

D.M. Farmer - Head

W.H. Bell
R.H. Bigham
* K. Gantzer
L.F. Giovando
* R. Hlady

* Left during 1974

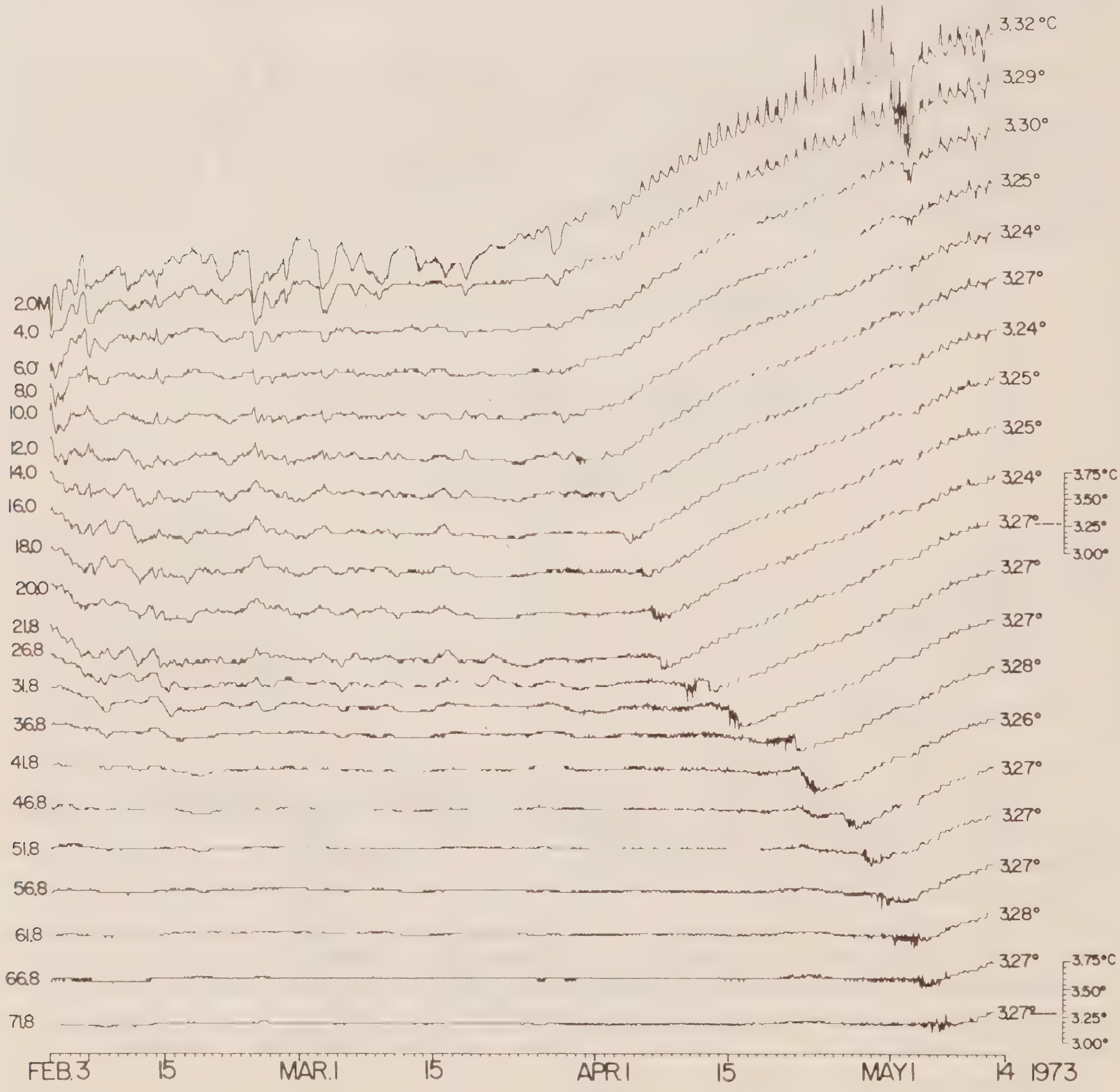
G. Kamitakahara
L.P. Landry
J.H. Meikle
D.G. Sieberg
L.A. Spearing
J.A. Stickland

With the conclusion of the field program in Babine Lake, our attention has returned to saltwater studies. We have also spent considerable effort on upgrading and calibrating our instrumentation. A new portable field translation unit for producing plotted records from recording instrument tapes has been built to specification. Our library of computer routines for processing current meter data has been substantially increased. This year we also gained experience in radar-tracking drift drogues in order to study surface water movements.

The physical oceanographic phase of the task force study on the proposed extension of Vancouver International Airport has now been completed. The work included surface current studies using dye and drift drogues.

BABINE LAKE PROJECT

The extensive physical limnology field program in Babine Lake was concluded this spring with the removal of several thermistor chains moored beneath the ice. These instruments recorded temperature every 80 minutes from just beneath the ice down to the lake bed. Analysis has now begun on these data which are providing a most detailed picture of the way in which the winter thermal structure of a deep northern lake is laid down. As the surface layer cools and deepens, the water in the deepest part of the lake gradually warms, rising quite sharply when convection reaches the bottom. Wind-generated disturbances penetrate to the deepest parts of the lake and the subsequent cooling is marked by large temperature fluctuations.



Temperature records taken at successive depths beneath the ice of Babine Lake in spring. Solar radiation penetrates the ice, warming the water beneath and causing a convective layer that increases in thickness with time.

This year the analysis of radiation induced penetrative convection beneath lake ice was completed. The results show that between 3 percent and 4 percent of the energy released by gravitational instability is recovered as potential energy due to entrainment at the foot of the convective layer. Data gathered this spring showed exactly the same type of convective development beneath the ice as had been observed in 1973, thus tending to support our opinion that the phenomenon is typical of ice-covered lakes.

Analysis of summer temperature data has revealed the repeated occurrence of internal surges propagating along the lake. These steep non-linear internal disturbances have been observed in other long lakes, but their origin has not yet been satisfactorily explained. The special feature of the Babine data is that by observing them at several locations along the lake we are in a position to learn more about their generation. The surges appear to start as long internal waves in the southern basin that steepen sharply as they propagate along the lake. This analysis of internal surges is being carried out jointly with C. Lee of the Institute of Oceanography, UBC.

FIORD OCEANOGRAPHY

Data reduction and analysis of the large set of current observations from Howe Sound is now underway. A preliminary look at the data shows up inlet currents of as much as half a knot persisting for several days at 10 to 30 metres depth.

In April we obtained a short series of current measurements at the junction of Rupert and Holberg Inlets on Vancouver Island. Its proximity to a major copper mine and the recent rapid increase in turbidity make this an area of practical concern. It is also a region of considerable scientific interest for it represents an extreme example of rapid deep water exchange in a fiord.

Three current meters were moored behind the sill of Quatsino Narrows. On every flood tide during the 21 days of measurement the deepest instrument (5 m above the bottom) registered a strong current (up to 3 knots), far in excess of the measured current at shallower depths. That the rapid bottom flow was indeed a turbulent density current, resulting from high salinity water spilling over the sill, is confirmed by the simultaneous conductivity and temperature measurements.

The intense scouring action of this current and its subsequent upward deflection near the opposite shore may account for the high level of observed turbidity. The oceanographic problem is of particular significance, since the disposal of mine wastes involves bottom transport through this highly active area into the deep basin of Holberg Inlet.

HEAT BALANCE IN AN OYSTER PRODUCING SOUND

This summer we undertook a heat balance study of Pendrell Sound, an important oyster spat producing area. The purpose of this work was twofold: (1) To gain an understanding of the formation and maintenance of the unique oceanographic conditions that favour oyster spat production, and (2) to estimate the advection of surface water into and out of the sound. Minimal advection is of crucial importance to the survival of oyster spat, which must remain in the warm surface waters of the sound for up to three weeks in larval form. The intention is to relate fluctuations in the estimated heat balance, which necessarily excludes advective effects, with horizontal motions measured by recording current meters. The substantial data reduction work is now almost complete and analysis is expected to be concluded by the summer of 1975. This work is being carried out jointly with Dr.M.Miyake and W.Buckingham of the Institute of Oceanography, UBC.

The launch Squamish moored alongside the Fisheries' barge in Pendrell Sound. The launch was used in a study of thermal structure and its influence on the survival of oyster larvae.

Numerical Modelling Section

R.W. Stewart - Head

P.B. Crean
M. Foreman

R.F. Henry
P.J. Richards (Computing Services)

A system of joined one- and two-dimensional numerical models of the barotropic tidal cooscillation in the waters between Vancouver Island and the mainland has been developed. The model system is operated by prescribing elevations at two boundary openings, to the south at the entrance of Juan de Fuca Strait and to the north in Johnstone Strait. An extended program of testing involving respectively the major semi-diurnal (M_2), diurnal (K_1) and mixed (61 constituent) tides has been carried out.

The M_2 trials were concerned essentially with optimizing results by adjustment of frictional coefficients and the effects on the solution of the parameterization of important conveying channels which, though of limited geographical extent, are characterized by strong tidal currents.

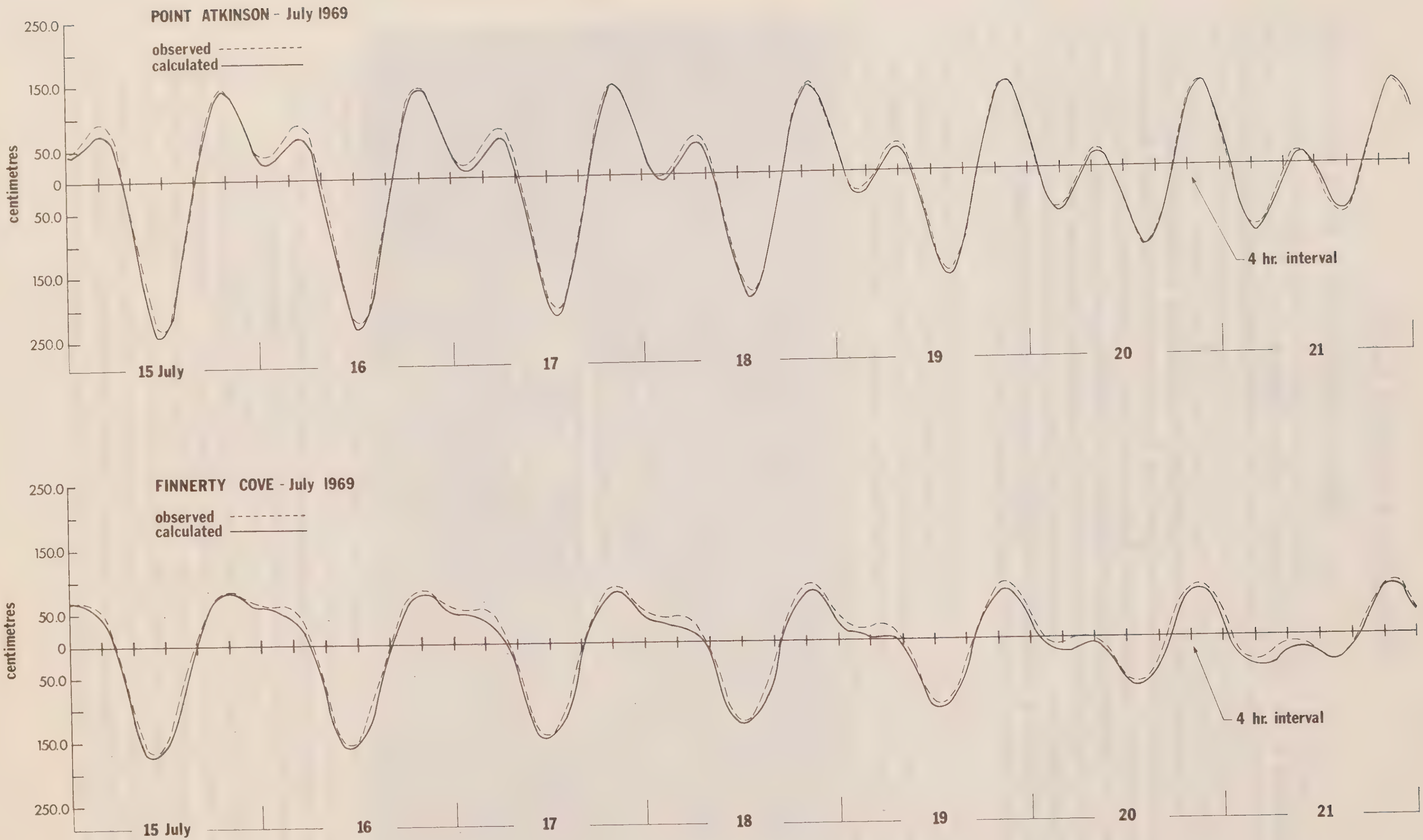
The most important results derived from this work concerned the influence of wave speed and frictional dissipation in Haro Strait on the tidal elevations of the Strait of Georgia and the Puget Sound system. These features had not been apparent in earlier versions of the model where elevations were prescribed at several boundary openings of the Strait of Georgia.

K_1 tidal trials showed that the overall frictional classification appropriate to an optimal representation of the M_2 tide was smaller than that required for the K_1 tide.

To obtain as complete a representation of the tides as possible trials employing a mixed tide included the 61 constituents available from the one-year tide gauge record. It was found necessary to reduce the overall frictional dissipation further to optimize agreement between the predicted elevations based on gauge data and those computed by the model for the interior of the region.

Joint field programs have been undertaken with the Institute of Oceanography, University of British Columbia, with the aim of providing information for future numerical studies on important problems concerning the basic circulation within the system.

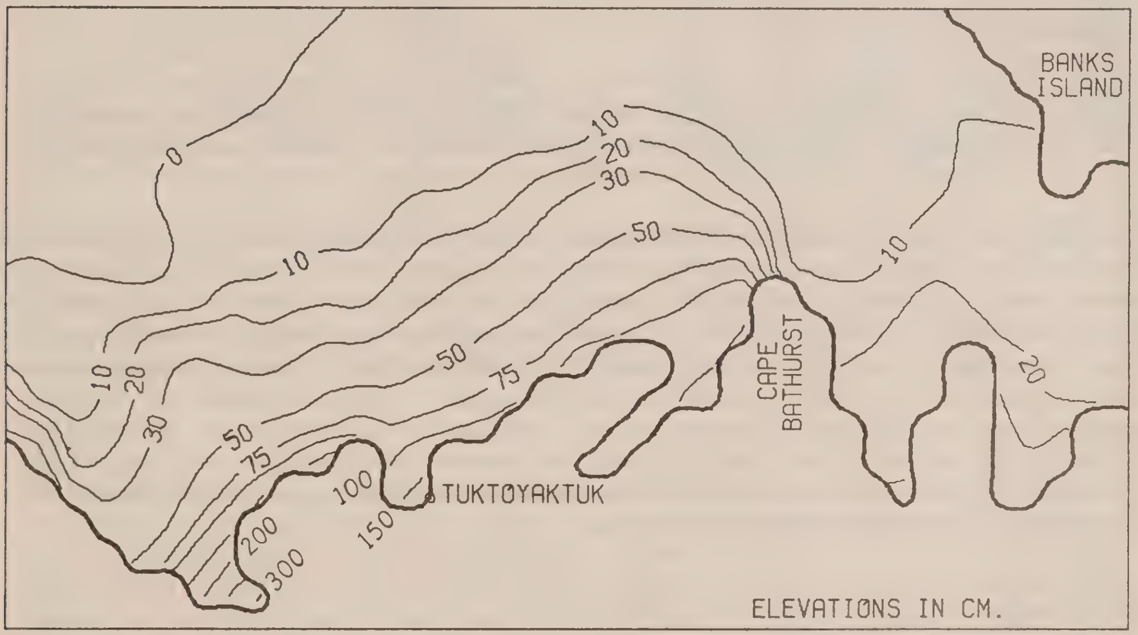
These include the float tracking and CSTD measurements in the Fraser River plume. Such tracks permit useful comparisons between the computed barotropic tidal velocities and the observed motion of the upper layer. In addition an extensive body of STD data has been obtained in Juan de Fuca Strait pertinent to the exchange of water between the system and the ocean. These measurements coincided with current meter observations by the Tidal and Current Section over a



A comparison of predicted tidal elevations based on harmonic constants obtained from observations (dashed curve) and the elevations computed by the numerical model (solid curves) for two representative locations, Point Atkinson (Strait of Georgia) and Finnerty Cove (Haro Strait). The sequence of tides is reasonably typical and extends over the period of July 15 to 21, 1969.

cross section of the Strait. These observations included station patterns occupied in collaboration with a vessel from the University of Washington. One of the important aims in this work is the provision of open boundary information pertinent to future three-dimensional numerical studies. (Crean)

A large-area storm-surge model of the southern Beaufort Sea extending from Amundsen Gulf to Point Barrow and north to 74°N has been developed. Simulations of severe storms with northwest winds made on this model show surge heights comparable with those in actual surges recorded. A small-area model is being programmed for more detailed study of the shallow Mackenzie Bay-Cape Bathurst shelf, which the large-area model indicates to be the area most prone to surges. (Henry)



Computed surge heights on Mackenzie Bay-Cape Bathurst shelf in response to prolonged 40-knot northwest wind.

Offshore Oceanography Section

J.F. Garrett - Head

* K.B. Abbott-Smith
C. de Jong
* A. Hartley
R. Hlady
L.S. Kuwahara
E.L. Luscombe (CELL)
E.W. Marles
B.G. Minkley
D.B. Smith (Computing Services)
S. Tabata
R.E. Thomson

* Left in 1974

Members of this group were engaged in a wide variety of physical oceanographic activities this year, reflecting the broadening scope of the regional program and differing interests of the scientists concerned.

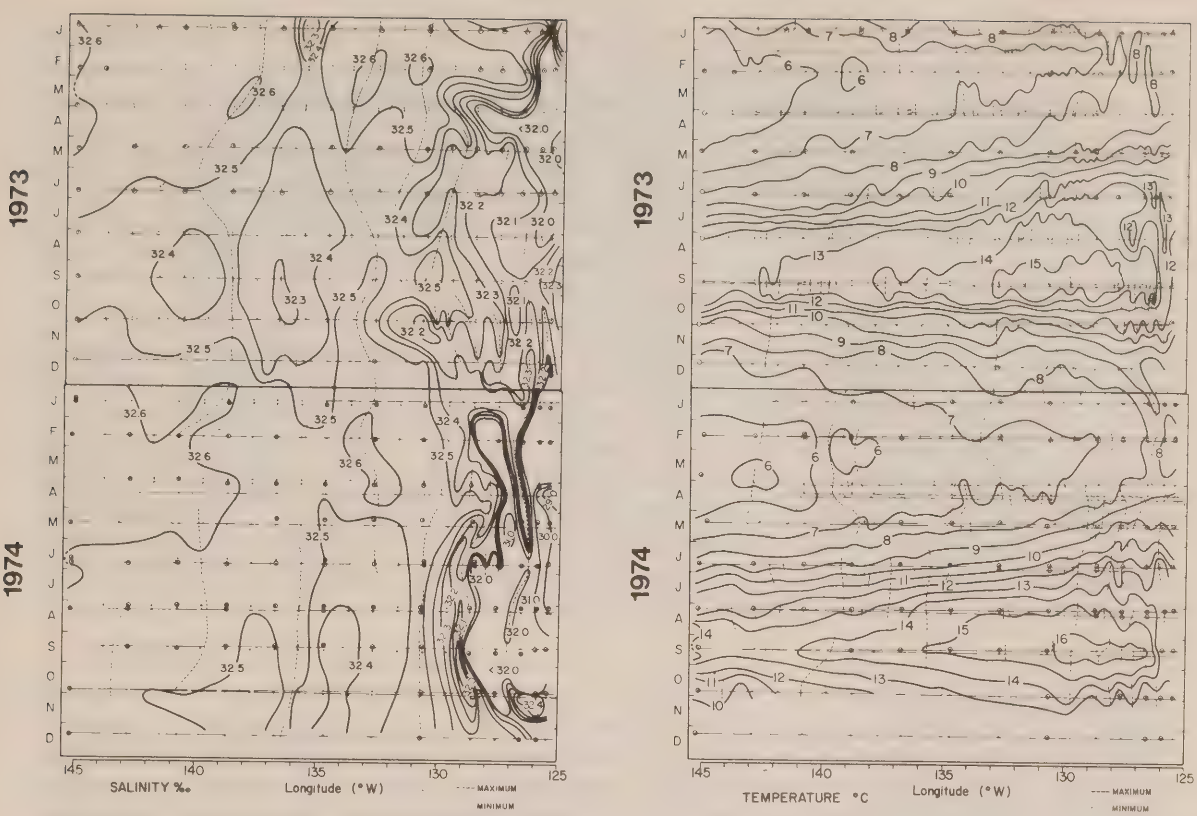
WEATHERSHIP OCEANOGRAPHY

This was the 18th year for the oceanographic time series at ocean weather station P (50°N, 145°W) with oceanographers aboard for seven of the ten patrols. Physical oceanographic data was published in data report form, bringing the total number of volumes in the series to 60.

A change in our method of operation began in November when a contract was let to Chemex Labs Ltd., of North Vancouver, to carry out the shipboard data and sample collection on a trial basis on one of the ships. If this proves satisfactory it is planned to extend this to both ships and eventually to the production of data reports, thus freeing staff for programs of a more experimental nature. The importance of this time series has been heightened by increasing concern over climatological fluctuations and their possible effects on world food supplies. Withdrawal of most weatherships by other countries has also increased the value of the series. (Garrett)

OCEANOGRAPHY ALONG LINE P

Certain types of oceanographic observations are made at regular 6-week intervals along line P (from Juan de Fuca Strait to station P) and almost continuously at ocean station P. Purpose of the observations is to determine the variability of conditions off the Pacific Coast and to monitor these conditions for possible fisheries, defence and pollution applications. The major task at the moment is the processing and reduction of the large amount of oceanographic data collected since 1962 to analysable format. This will hopefully be completed within the next year.



Salinity (°/oo) and temperature (°C) at a depth of 3 m along line P during 1973 and 1974. Hydrographic or salinity-temperature-depth stations are indicated by ⊙ while 3 m observations are shown by ●. Dashed lines indicate times when continuous observations were made. Some of the relative maxima and minima have been noted to persist for 2 years.

In the meantime the quality of surface (3 m) temperature and salinity observed continuously along line P has improved considerably during the past two years and has permitted the resolution of fine surface features along the line. Areas of relative maximum and minimum temperature and salinity have been determined with more confidence than in the past. Sea surface temperature measurements made along line P during 1974 indicate that while the winter temperatures in 1974 were generally similar to those of the previous winter, the summer temperatures were generally higher than during the previous summer, by approximately 1°C. There appears to have been a warming trend along the line since the summer of 1973. Within a few hundred kilometres of the coast of Vancouver Island the salinity was generally lower in 1974 than in 1973. However, farther offshore the salinity was slightly higher, about 0.1°/oo, in 1974. The 32.0°/oo isohaline extended approximately 200 km farther offshore than during 1973.

The relative minimum salinity observed halfway along the line has been found to persist from January 1973 through December 1974. A somewhat less-marked salinity minimum occurred to the east of station P. Between these two minima occurred a relative maximum. All of these features have been observed to persist for at least two years. At other parts of the line a number of relative maxima and minima occurred which lasted for less than one year. The positions of the main salinity minimum coincide with those of minimum temperature as did those of the salinity maximum and maximum temperature.

Where maxima occurred the geostrophic surface current (which could be determined only when a sufficient number of STD stations were occupied along the line) was directed northward; where minima occurred it was directed southward. However, it would require more data to determine if this occurrence of geostrophic flow is always associated with the relative maxima and minima of temperature and salinity. If this tendency holds it will be possible in the future to predict, in a crude way, some aspects of the detailed oceanographic transport off the coast of Vancouver Island. (Tabata)

PLANETARY WAVES

Work is also continuing on the explanation for the relatively large high frequency vertical variability of temperature in certain regions along line P. There are indications that these variations possess a dominant Fourier scale length of between 30 to 60 metres and that they are in some way associated with bottom topographic effects.

In connection with this and the high variability in other parameters along line P (e.g. dynamic height anomaly), a theory of trapping of planetary wave motions over the rough bottom topography regime off the B.C. coast is being developed. (Thomson)

POTENTIAL VORTICITY WITHIN THE OCEAN

An extensive analytic study of the balance of total vorticity (planetary vorticity, relative vorticity plus topographically induced vorticity) applicable to any ocean has been completed. This study has shown that the only way vorticity in the ocean can be altered is via molecular diffusion at the oceanic boundaries or via advective input through the free upper surface. The steady state balance is then between the surface wind stress and molecular diffusion at solid surfaces.

This work has further demonstrated that horizontal turbulent mixing of potential vorticity is not capable of generating net vorticity within the ocean as some recent theories have suggested. Consequently the sverdrup relation is an accurate description of the vorticity balance in the oceanic interior. (Thomson)

PHYSICAL OCEANOGRAPHY OF THE B.C. COAST

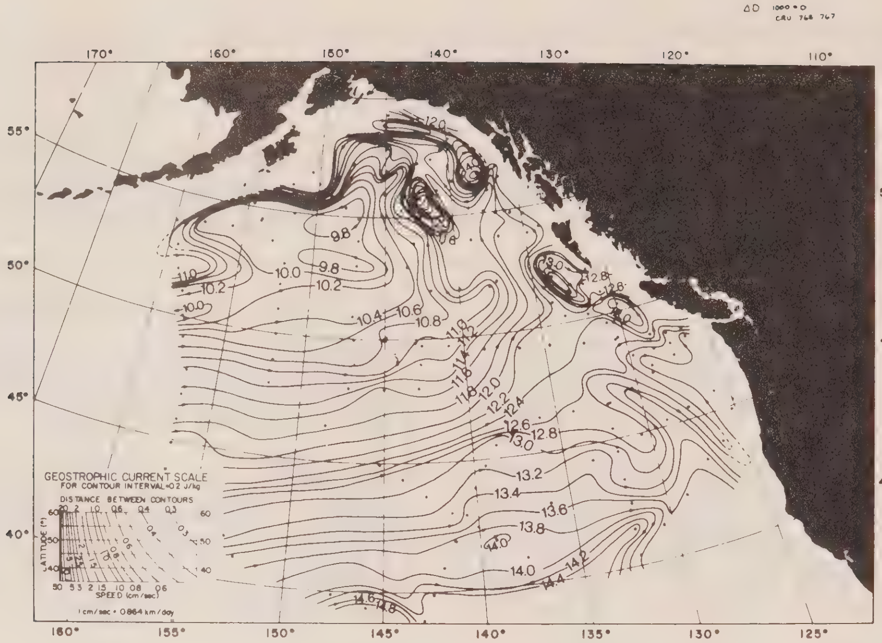
A series of popular articles on the Physical Oceanography of the Canadian west coast is being written for Pacific Yachting, a magazine of over 15,000 circulation published in Vancouver for boaters of B.C. and the U.S. Northwest.

The least known aspect of physical oceanography off the coast of British Columbia is the current pattern. Except for a small number of drift studies, the only information consists of the geostrophic currents inferred from studies of oceanographic properties in the region.

During 1973 the geostrophic transport of water (relative to the 1000-decibar surface) along the section of line P within 400 kilometres of the coast of Vancouver Island was noticeably southward. This southerly transport has been noted to occur from time to time previously, but it appears to have been more persistent in 1973 than in the past.

An examination of the historical synoptic data collected in the past, between 1950 and 1967, indicates that during the summer such southward transport along the coast of Vancouver Island is a common occurrence, although the width of the current varies from year to year and the spatial extent varies from time to time. During 1958 particularly and in 1961 the southerly transport was better developed than in other years. The southerly flow is not continuous along the Pacific coast but appears to be associated with the occurrence of eddies or a meandering current off the coast.

One of the more striking examples of this is the anticyclonic eddy with its centre located a few hundred miles west of Sitka, Alaska. It occurred at the same location in the spring and summer of 1958 and during the summers of 1960 and 1961. The geostrophic current (surface) and the volume transport of the eddy was as high as 34 cm/sec and 10 sverdrups (10^6 m^3/sec), respectively. These magnitudes were in excess of the corresponding values in the region of the strongest portion of the Alaska Current and are therefore significant to the circulation system in the northeast Pacific Ocean. Because such an eddy is located in the path of the proposed Trans-Alaska Pipeline System (TAPS) tanker route it is likely to have bearing on future problems related to the movement and dispersion of spills of crude oil in the area. (Tabata)



Geopotential anomaly (Joules/kilogram) at the surface relative to 1000-decibar surface in the northeast Pacific Ocean during late spring of 1961. Anti-cyclonic eddies lying off the coast frequently result in poleward flow along the coast.

GRAVITY WAVES IN THE ATMOSPHERE

The propagation of gravity waves in the atmosphere in the presence of a mean wind having a random velocity shear in the vertical is being investigated. Results indicate in more detail the effect of advection on growth or decay of such waves as they propagate upwards. (Thomson)

BEAUFORT SEA SURFACE CURRENTS

As part of the special study to determine the potential hazards of exploratory drilling for oil in the Beaufort Sea Continental Shelf, a program of surface current measurements was attempted in the summer of 1974. Three objectives of the study were:

1. to measure the near surface currents in open water regions,
2. to determine whether there were persistent features, and
3. to study the responses to winds and changing outflow of the Mackenzie River.

The results will help estimate the probable effects of the currents on the movement of spilled oil or other contaminants.

In view of the large area to be covered (200 miles x 100 miles) and the already heavy committment of the available ships, it was decided to

conduct the study entirely with aircraft. A drogue and panel marker system was developed which could be dropped from fixed wing aircraft equipped with Decca navigation, and which was visible from distances of 3 miles at 3,000 feet. Attached to this was a VHF radiobeacon for tracking the drogues from distances up to 30 miles.

Although this system turned out to be less than perfect, as might be expected from a first try, all problems with it were overshadowed by the reluctance of the ice pack to move out of the area of interest. By modifying the drifters to work in shallower water and by placing some radiobeacons on ice floes enough observations were obtained to indicate that the technique was practical, and that the surface current regime was highly dependent on local weather patterns.

The field work and data analyses were carried out under contract by Dobrocky Seatech of Victoria. (Garrett)

Frozen Sea Research Group

E.L. Lewis - Head

J.D. Bradbury	P. Oswald
J.W. Butcher (Computing Services)	R.G. Perkin
R. Cooke	D.L. Richards
A. Koppel	R.B. Sudar
R.A. Lake	D.R. Topham (Consultant)
A.E. Moody	E.R. Walker
S.W. Moorhouse	P. Wadhams (Postdoctoral Fellow)

Four field operations were carried out during the year, double our average. Three in Greely Fiord (80°36'N, 79°35'W) allowed observations covering the fiord's response to runoff before and during an entire melt season.

Measurements include river runoff (made by both wading and dye release techniques); snow depth and density variations with time, glacier and iceberg movement; sea ice movement and melt. In addition the standard oceanographic measurements of temperature and salinity were carried out in April using tracked vehicles, and in August from a boat. The variations of these parameters along the fiord were noted.

During the first of these trips in April current meters were placed on the sea bed near the sill of the fiord and just beneath the sea ice cover. The instruments telemetered both speed and directional information back to the base until the summer break-up.

Four streams running into d'Iberville Fiord were gauged during 1974. Although one of these gaugings was qualitative, the pattern of runoff from south-sloping, north-sloping and glaciated basins was established. Precipitation recorded at the site showed 0.64 inches of rainfall in one day in August and well over an inch in three days. These amounts are very large compared with precipitation records in the high Arctic, and caused the highest stream water flows of the year with consequent heavy erosion of thaw-softened banks.

A single field operation in Cambridge Bay (69°N, 105°W) in February attempted to answer some of the questions regarding water movement in mid-winter that had been posed by our previous studies. Our ultrasonic current meter (a Christian Michelsen Institute design) which will measure velocities down to 1 mm/sec was deployed at various locations with most interesting results. Currents associated with internal waves, seiche frequencies of the bay, tidal fluctuations and the movement of dense water masses down the sloping sides of the bay were recorded.

Time-lapse cameras with timers operating to an accuracy of ±2 seconds a day at temperatures down to -40 C were developed and used in the field. Installed in August, for example, they can be programmed to switch on the following March and thereafter take up to 3,600 photographs at programmed intervals. The same timer was used to trigger automatic stream water samplers developed for use with the dye injection technique for stream flow. The year saw the first installation of modified Aanderaa current meters for use where the earth's horizontal magnetic field is insufficient to provide a directional reference. Telemetry equipment was attached to these instruments and the complete deployment system, for use through a sea ice cover in up to 800 metres water depth, received its first operational testing with great success.

Professional staff have been heavily involved in task forces concerned with industrial developments in Arctic regions. These relate primarily to industry proposals to put mine tailings into the sea at various locations, and to the 'oil-in-ice' program of the Beaufort Sea Project. Many Canadian Arctic offshore projects come to Frozen Sea Research Group for comment on physical oceanographic consequences, and this aspect of FSRG work now occupies approximately 50 percent of the Group's time.

A study of the Arctic water-shed in the vicinity of FSRG Greely Fiord Base has begun in cooperation with the Glaciology Division of Inland Waters and the Halifax office of Water Survey of Canada.

Ocean Mixing Section

P.W. Nasmyth - Head

A.E. Gargett
G.W. Chase
R.C. Teichrob
L. Beauchemin (CELL)

An investigation of the occurrence of turbulent mixing with respect to oceanic fine structure has been carried out, using data obtained in 1972 with the towed turbulence system in cycling mode. The signal from a high frequency response platinum film thermometer is used, with the local mean vertical temperature gradient, to produce variables proportional to the heat flux and to an eddy diffusivity for heat. Along with measured values for the local salinity and density gradients, this information has been used to examine some questions of interest to the general understanding of turbulence in the ocean.

Results indicate that the oceanic thermocline in the North Pacific can be divided into inactive and active regions, on the basis of differing mixing characteristics. Inactive regions have monotonic vertical profiles of temperature, salinity, and density, and only about 5 percent of the volume is turbulent. Turbulence in such regions is probably caused by sporadic shear instabilities. In contrast, active regions are characterized by substantial inversions of temperature and/or salinity with depth, although the density profiles remain stable for vertical scales larger than roughly one metre. Turbulent mixing occupies an average 12 percent of the volume of such regions, and may be due to either or both of two mechanisms: increased shear, generating turbulence at the boundaries of intrusive features which produce the temperature and salinity inversions; and doubly diffusive processes which become possible due to the differing molecular diffusivities of salt and heat, in regions where the temperature and salinity gradients have the same sign.. The observations indicate that the latter mechanism does operate in active regions, where the local property inversions are favourable. The main results suggest that much of the vertical mixing of properties in the upper layers of the ocean may result from the quasi-horizontal processes which produce vertical fine structure.

Work is proceeding on the software development needed to carry out analysis of the high-frequency temperature and velocity data recorded during the major cruise carried out by the Section in 1973.

No new data have been collected this year. All available effort has been devoted to development of a new system for microstructure/turbulence measurement from Pisces IV. A compact, high-capacity data acquisition unit has been designed and constructed by contract. This unit will accept a mix of analogue and digital inputs up to a total of 32 channels, and records all signals serially in special format on video tape. New miniaturized instrumentation for temperature, velocity and conductivity is in preparation and preliminary sea trials will be undertaken in January 1975.

It has become clear that Pisces IV is not sufficiently stable in either pitch or yaw in mid-water flight to meet the requirements of this program. Wind tunnel tests have therefore been undertaken on a model and the basic requirements for a set of stabilizing fins have been established. A contract is now being negotiated for design, construction and fitting of full-scale fins on the Pisces IV.

Remote Sensing Section

J.F.R. Gower - Head

J.S. Wallace	J. Marko (Contract)
R.A. Neville (NRC Postdoctoral Fellow)	I. Daniel (Contract)
	D. Truax (Contract)

Satellite imagery continues to increase in usefulness and variety for ocean and ice studies. Digital ERTS-1 data was processed to enhance joint radiance changes over water and the 4-band spectral signatures of changes due to waves, silt and atmospheric effects were investigated. A variety of ERTS-1 image products was collected and used to reduce the properties and extent of arctic ice, and of the Mackenzie River plume.

NOAA satellite visible and infrared imagery is being used increasingly for studies of ice. Digital NOAA data tapes have been processed to enhance ice features, correct for geometrical image distortions, and enhance surface temperature features.

Air photos were taken in support of studies of the Fraser River plume using motor-driven 35 mm cameras with fisheye and wide-angle lenses mounted in a light aircraft. These showed the extent of the surface plume at different states of the tide and gave some information on the movements of drifting surface targets. Air photos were also taken over Quatsino Narrows to show the distribution of mine tailings in surface water. Tests of the Kodak SO-224 water penetration film were also carried out.

Data from test flights with the Boeing 720 research aircraft on use of a navigation doppler radar to indicate sea surface currents were analysed, and showed that the technique has promise for rapid coastal current surveys.

Work with the Astronomy Department of UBC in development of the silicon diode 256 channel spectrometer continued until the instrument was delivered in September. It is now being prepared for flight tests early in 1975, and

will be used primarily for ocean colour measurements under daylight illumination. The instrument is also suitable for airborne signature measurements in a variety of other fields.

An LTN-51 inertial navigation system was bench and flight-tested for a variety of tasks and has now been incorporated into the MIDAS inertial navigation and data acquisition system, which was delivered in September by Macdonald Dettwiler Associates. The unit can provide the basic navigation, attitude measuring and data handling package for most airborne sensing programs.

BEAUFORT SEA PROJECT

A.R. Milne - *Project Manager*
A.L. Watson - *Project Coordinator*
B.D. Smiley - *Project Biologist*
D.L. Aanhout - *Secretary*

The Beaufort Sea Project is a major Arctic marine environmental assessment program financed by the Federal Government and 18 companies of the Arctic Petroleum Operator's Association. Most 1974 research for the 32 project studies was carried out in the region of the Beaufort Sea in which offshore exploration leases have been granted to oil companies.

The Institute of Ocean Sciences, Patricia Bay is the lead agency in the management of the Beaufort Sea Project. The Project Manager reports to a DOE Beaufort Sea Steering Committee headed by Dr. R.W. Stewart, Director General, of the Institute. Other members are Dr. J.Clodman, Director of Meteorological Service and Dr. A. Macpherson, Director General, Western Region, Environmental Management Service.

Under the terms of the agreement between the Federal Government and the oil industry, signed May 15, 1974, Government will coordinate the Beaufort Sea environmental studies and maintain cost control. The Government also retains final authority over the specifications of works, and of the award and administration of contracts. The Project Office has undertaken these duties in addition to the general expediting of field operations (caching of fuel stocks, chartering aircraft, provisioning and outfitting ships, supplying field camps) out of Polar Continental Shelf Project at Tuktoyaktuk.

Beaufort Sea Project Interim Reports have been compiled and published under the supervision of the Project Office. The target date for completion of studies is November 1975.

MV Pandora II, on long-term charter to the Institute, arrived at Patricia Bay in June to prepare for her first assignment. As mothership to Pisces IV she spent the summer in the Arctic on duty for the Beaufort Sea Project.

Two charter vessels, the MV Theta and the submersible-support vessel MV Pandora II were used during the summer, the former as support for offshore marine geophysical studies, the latter for oceanographic, fisheries and biological studies. The ships left Victoria in early June escorted by the ice-breaker CCGS Camsell. They were delayed by severe ice conditions near Point Barrow and did not reach the study area until August 9, about three weeks late. Weather and ice conditions improved later in the summer but the ships were not able to reach all areas originally planned.

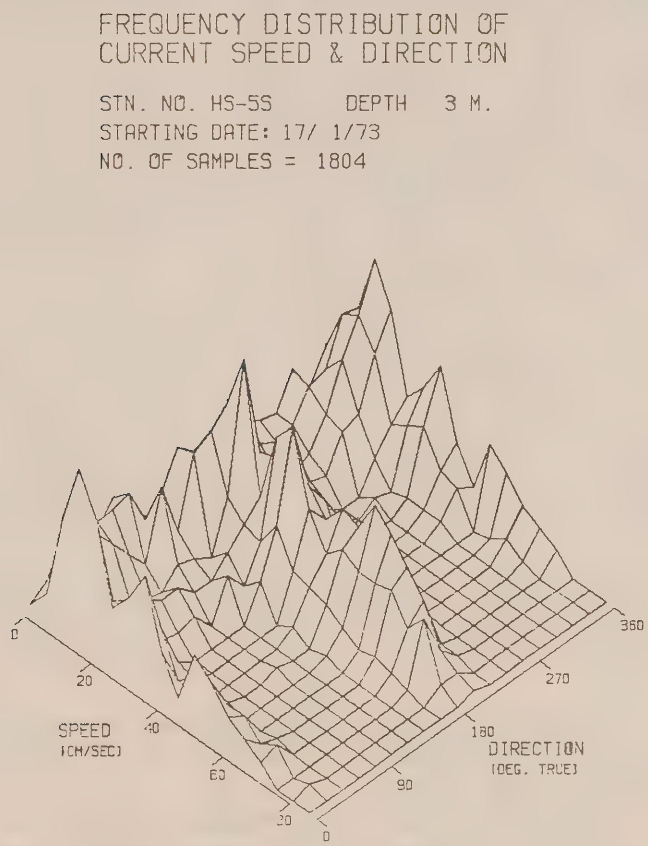
With the threat of an early freeze-up and the proximity of the polar ice, the MV Theta and MV Pandora II left the Beaufort Sea on September 7. The somewhat restricted cruises hindered some studies but other transport including helicopters and fixed wing aircraft were used as alternatives for data and sample gathering.

The field programs most severely affected by the adverse sea-ice conditions were studies of ice scouring of the sea-bottom, tides and bottom currents, and surface currents. The researchers involved from the Institute of Ocean Sciences, Patricia Bay, and the Geological Survey of Canada are now assessing the implications of the shortened season on their work and are developing proposals for completion of their work in 1975.

Scientists of the Arctic Biological Station and the Freshwater Institute carried out studies on fish, marine mammals, bacteria and aquatic invertebrates.

The Canadian Wildlife Service accelerated on-going research of sea-birds, seals, whales and polar bears. Physical and chemical oceanographic studies, including 'oil-in-ice' experimentation, are being undertaken by the Institute of Ocean Sciences, Patricia Bay.

Other work involves geophysical studies by the Geological Survey of the Department of Energy, Mines and Resources, meteorological studies by the Atmospheric Environment Service and oil clean-up studies by the Environment Protection Service.



A three-dimensional graphical presentation of the relationship between current speed and direction, representative of results obtained in a study of circulation and flushing in Howe Sound by Coastal Zone Oceanography Section.

OCEAN ENGINEERING DIVISION

Computing Services Section

K. Teng - Head

R.E. Johns
J.W. Butcher (with FSRG)
A.N. Douglas (with Tidal and Current)
C.G. Morgan (with Ocean Chemistry)
P.J. Richards (with Numerical Modelling)
D.B. Smith (with Offshore Oceanography)
A.L. Woollard (with Tidal and Current)

During 1974 K. Teng and R. Johns participated in a study that examined regional departmental computing requirements for the next several years. Possible solutions included common service bureau, in-house hardware, and facilities management. At year's end a report with findings and recommendations was being prepared by Ottawa members of the West Coast EDP Committee for presentation to senior regional management early in 1975. At present the bulk of our external computing is processed at the UBC Computing Centre through a Comterm remote batch terminal located at Patricia Bay.

Considerable hardware was acquired by various groups. Computing Services added a magnetic tape drive to the Comterm for retrieving plot files from the UBC computer system; an HP 2100A mini-computer and a Calcomp 563 plotter to perform off-line plotting, and a Tektronix 4010 graphical display with hard-copy unit for previewing plot information. Coastal Zone acquired a PDP 8/f system with a 6-channel chart recorder for field translation and display of data collected on Aanderaa current meter tapes.

The Federal Building (Tidal and Current) system was upgraded with a 32K HP 2100S processor and a Versatec 1100A printer/plotter. The HP 2116B was moved to Patricia Bay to become the CPU for the primary data conversion system, freeing the HP 2115A for shipboard use in 1975. Ocean Mixing purchased an HP 5451B Fourier Analyzer (including a 32K HP 2100S computer and various peripherals) to supplement the PISCES data acquisition system and to perform related data processing.

Field Hydrography acquired a second PDP 8/e for use on the CSS William J. Stewart. In the fall, additional hardware and software was ordered to bring this system and one on the CSS Parizeau to a similar enhanced level.

The Ocean Chemistry PDP 11/10 was upgraded with a magnetic tape drive and a sub-system to handle laboratory peripherals. This system was on board the CCGS Quadra during the GATE voyage.

A computerized financial accounting and reporting system went into operation for fiscal 1974-75. Programming was done by K. Teng and J. Inkster (on contract). Data entry to input forms is the responsibility of the Accounting Section; keypunching is done by Alpha-Data (on contract); operational runs are performed by E. Wong (on contract). This system is providing more timely and more usable information to financial managers than was formerly available.

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent

F.S. Green, Assistant Marine Superintendent (deck)

D. Marr, Assistant Marine Superintendent (engineering)

The Pacific Region Ship Division provided ship, launch and depot support as required for the 1974 hydrographic and scientific projects. These activities are briefly described.

CSS PARIZEAU

Master, A.G. Chamberlain

Chief Engineer, B.N. Aaron

Following annual refit and drydocking at Yarrows Ltd., Victoria, B.C., CSS Parizeau was employed in the following roles: current metering (DOE), offshore oceanography (DOE), biology (IOUBC), physics (IOUBC). From March 15 to October 20 this vessel was substituted for CCGS Quadra on weather station P while Quadra had been assigned during this period to a major international exercise, the GATE in the equatorial Atlantic. Despite her small size, Parizeau rendered yeoman service on this assignment and recorded no loss of time from station. Later in the fall a current meter project was supported for DOE prior to the ship's annual refit.

CSS WM.J.STEWART

Master, K.J. Sjoholm

Chief Engineer, J.D. Henderson

CSS Wm.J.Stewart was drydocked and refitted in Yarrows Ltd., Victoria, B.C. and prepared for the hydrographic survey season which began April 16. The areas of work this year included Georgia Strait, Skeena River estuary, Barkley Sound and Jervis Inlet. Hydrographic activity ended in mid-October and the ship was prepared and closed down for its usual winter decommission period.

CSS VECTOR

Master, J.C. Marston

Chief Engineer, G.W. Clouston

Following the January annual refit and drydocking, CSS Vector supported the following activities: UVic (biology, chemistry and 'man-in-the-sea'), IOUBC (physics, biology, chemistry), EMR (geology), DOE (chemistry, research and development), PEI (chemistry). Areas of operations were along the southern B.C. coast including mainland inlets and west coast of Vancouver Island.

CSS RICHARDSON

Master, C.M. McIntyre | Chief Engineer, J.N. Henderson

A fairly active year was recorded by CSS Richardson. Following preparation for service this small vessel was employed by DOE users for a sewage dispersal experiment, a Fraser River plume study, current metering and revisory surveys.

CFAV LAYMORE

Master, M.J. Dyer | Chief Engineer, H.R. Doherty

CFAV Laymore continued to serve the scientific community under the existing joint financial arrangement, i.e. funding 75 percent DOE, 25 percent DND. Users were - IOUBC (chemistry, physics, biology, geophysics); DND (diver training, accoustics); UVic (biology, chemistry); PEI (ecology,chemistry),and Simon Fraser University (Fraser River studies).

MV RADIUM EXPRESS

Master, J. O'Sullivan | Chief Engineer, W. Butler

The Northern Transportation Company Ltd. charter vessel MV Radium Express completed its third successful season on the Mackenzie River hydrographic survey. Unfortunately the ship was later caught downriver by the early freeze-up with several other NTCL craft, and this may delay the start of the 1975 survey. A new aluminum, jet-propelled survey launch has been designed and constructed to replace the old Whaler I, a veteran of four arduous seasons in the north. Her sea trials look promising.

MV PANDORA II

Master, R. Dickinson | Chief Engineer, R. Ward

A new ship, MV Pandora II, joined the Division on March 12. This ship, on charter for five years, has the basic design characteristics of an offshore oil rig tender vessel modified to accommodate the submersible Pisces IV and staff and six scientists. As can be expected in a new ship we were beset with a multitude of teething problems. These have mainly been overcome and Pandora II is developing into a useful working unit. Her major role was in the western Arctic in support of the Beaufort Sea Project.

Following her return to Victoria Pandora II accommodated a submersible staff training program, and a submersible handling exercise in the rough open waters off Vancouver Island's west coast.

MV THETA

Master, K. Maro   Chief Engineer, A. Johannsen

MV Theta was chartered for a 100 day period,commencing on June 20, 1974, for the Beaufort Sea Project. This ship departed Victoria in early July and was escorted around Point Barrow and through the western Arctic by the CCGS Camsell. Like her accompanying vessel, Pandora II, she encountered exceptionally heavy ice conditions in the Beaufort Sea working areas which cancelled a large portion of the programmed work.

PISCES IV

Operations Officer, G. Meek   Chief Pilot, P.S. Le Gallais

Pisces IV, our deep-dive submersible,has also experienced innumerable teething problems but now shows signs of developing into a valuable instrument for oceanographers. The old wooden barge from which she operated has been replaced by the new mothership, MV Pandora II. The appointment of Maj. G. Meek as head of the Pisces IV team is expected to further improve the capabilities of this arm of the service.

CSL REVISOR

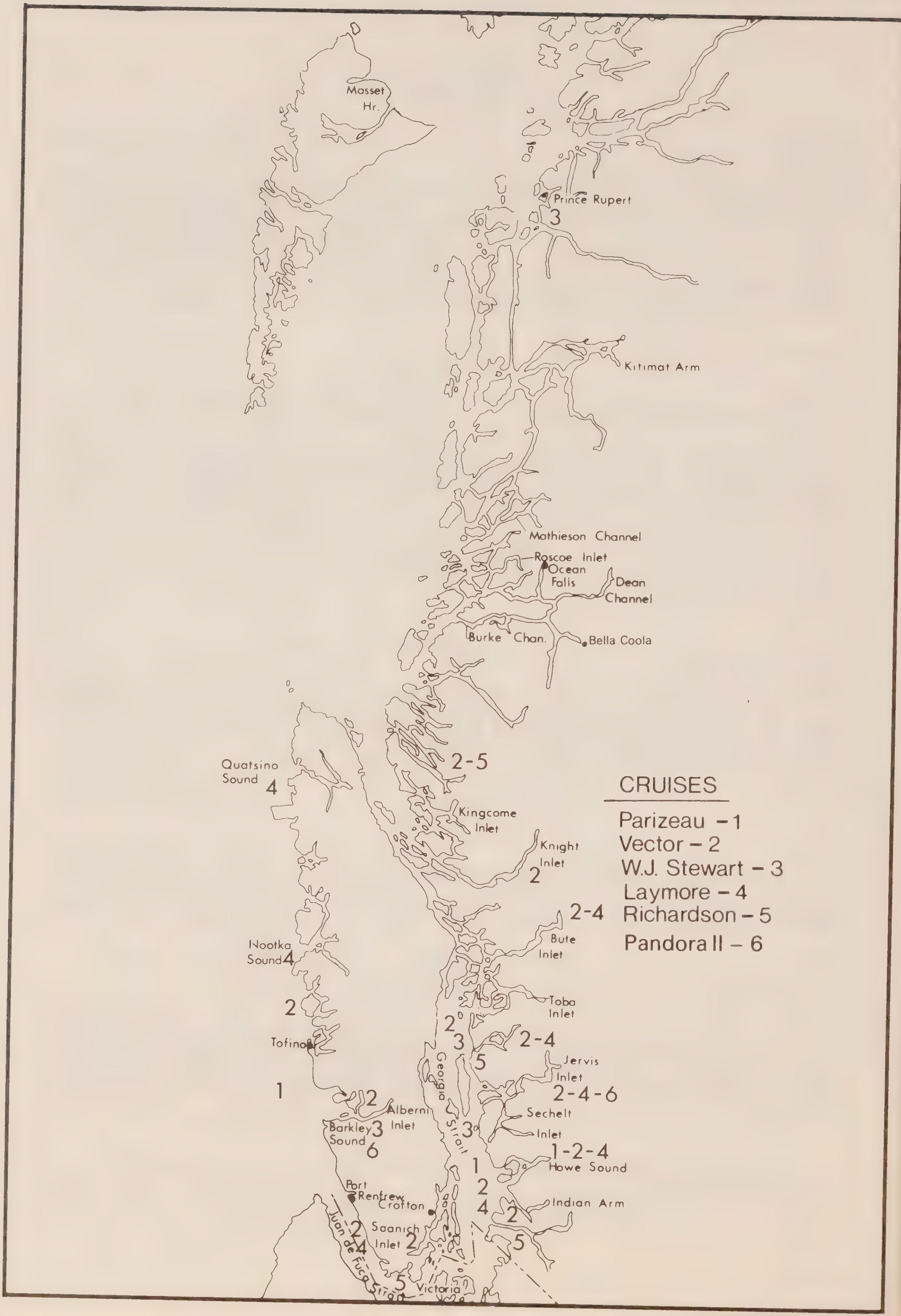
CSL Revisor's activities were somewhat reduced this year. She was used in conjunction with Pisces IV, Tidal and Current, Sailing Directions and Revisory Surveys operations.

LAUNCHES

All other launches operated very satisfactorily, with only very minor breakdowns, during the year. The credit for this favourable situation is shared by the Depot staff, by the operators and by the users.

DEPOT

The Depot and associated staff continued to perform multitudinous tasks of repair and maintenance of launches, building maintenance and the construction and repair of a variety of objects for Pacific Region.


Masset Hr.
Prince Rupert
3
Kitimat Arm
Mathieson Channel
Roscoe Inlet
Ocean Falls
Dean Channel
Burke Chan.
Bella Coola
2-5
Quatsino Sound
4
Kingcome Inlet
Knight Inlet
2
2-4
Bute Inlet
Nootka Sound
4
2
Toba Inlet
2
3
2-4
5
Tofino
Jervis Inlet
1
2
2-4-6
Alberni Inlet
Barkley Sound
3
6
Georgia Strait
3
Sechelt Inlet
1-2-4
1
Howe Sound
2
4
Port Renfrew
Crofton
2
Indian Arm
2
Saanich Inlet
2
4
5
Juan de Fuca Strait
5
Victoria
CRUISES
Parizeau - 1
Vector - 2
W.J. Stewart - 3
Laymore - 4
Richardson - 5
Pandora II - 6

MANAGEMENT SERVICES DIVISION

N.A. Todd - Chief

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

Much progress was made during 1974 with regard to the new Institute of Ocean Sciences which will house the staff of Pacific Region of Ocean and Aquatic Affairs and units of the Department of Energy, Mines and Resources.

Early in the year architectural consultants, Toby, Russell, Buckwell and Partners were appointed. A project management team consisting of the Department of Public Works, the Department of the Environment and the architects was set up. Under the direction of this team the Project Brief was completed in March and Departmental approval of the design was obtained in May.

Simultaneously a make or buy analysis was begun. Typical projects for both Departments were advertised in the March issue of the DSS Research and Development Bulletin. Following a strong response from industry the present programs of both departments, plus projected programs for the next decade, were analysed to predict the percentage of work which could be contracted out. This amounted to 61 percent for DOE and 48 percent for EMR in 1984-85. The two-volume make or buy report was completed in July and was favourably reviewed by the Ministry of State for Science and Technology.

Treasury Board approvals for the wharf and land facilities were given November 21, somewhat later than scheduled. A contract for $3,910,000 for construction of marine structures has been awarded to Fraser Pile Driving Company Ltd. Contracts for the buildings are to be let under the construction management concept which allows a number of smaller contracts to be awarded as required, to greater economic advantage. Estimated cost of the buildings is $16 million, with completion date scheduled for summer 1977.

Support required from Administrative Services increased during 1974.

The Personnel Unit was transferred from Management Services to the Area Personnel Office, Vancouver, early in the year. Personnel staff located in Victoria have continued to give high quality service, but problems have increased during the year and it is clear that strong steps must be taken to improve other personnel services if operating efficiency is not to be further adversely affected.

The computerized accounting system was made fully operational in 1974, due in large measure to the dedicated efforts of the Head of Com-

puting Services. Continuing development of the program will provide better management information service.

A start was made in establishing a modern materiel management system. Miss Caroline Szeto, an MBA student, studied regional needs and produced a report which will form the basis for an inventory control and materiel management system.

An operational and maintenance supervisor was hired to augment the small administrative section at Patricia Bay which was re-organized during the year. A mobile crane has been acquired for the site.

Need for more space for stores and equipment has been a continuing problem. It is being solved on an ad hoc basis at various locations until the Institute is completed.

The Library

L.S. Thomson - Librarian

In 1974 the Library continued its rapid growth, with the addition of nearly 600 new titles and an increase in journal subscriptions from 125 to 175. Although the collection is growing, it is still inadequate for our needs; a fact reflected in approximately 500 Interlibrary Loan requests to UBC, UVic, NSL, DOE and other institutions.

We look forward to the new Institute where the whole collection will be housed in one place, more accessible to all patrons.

The weathership Quadra docks beside her sister ship, CCGS Vancouver, in Esquimalt after taking part in GATE (the GARP Atlantic Tropical Experiment)

Task Force, Committee and Similar Activities

R.W. Stewart

Advisory Committee on Oceanic Meteorological Research (ACOMR) of WMO.

Joint Organizing Committee (JOC) of Global Atmospheric Research Program (GARP) - chairman.

Canadian National Scientific Committee for GARP.

SCOR - IAMAP - IAPSO Working Group on Air-Sea Interaction.

Application of Space Techniques to Meteorology and Earth Survey (COSPAR), Working Group.

Sea Use Council (USA) - vice-chairman.

Regional Board, Pacific Region (DOE).

Regional Board, Western and Northern (DOE).

Canada Advisory Committee on Physics (NRC).

Physical Oceanographic Commission (IAPSO) - chairman.

Beaufort Sea Steering Committee - chairman.

Arctic Environmental Steering Committee.

Arctic Waters Oil and Gas Advisory Committee.

West Coast Environmental Protection Agreement Steering Committee.

Royal Society of Canada Interdisciplinary Selection Committee.

W.N. English

Advisory Board on Marine Technology, B.C. Research Council.

Pacific Sub-Committee on Oceanography.

Regional Board, Pacific Region (DOE) - alternate.

Pacific Region Board Working Group on Abatement of Pollution from DOE Ships - chairman.

Regional Board, Pacific Region, Estuary Working Group.

Sea Use Council (USA) - alternate.

Military Colleges Advisory Board.

HYDROGRAPHIC DIVISION

Anderson, N.M.

Aerial Hydrography Project Sub-Committee of the Working Group on Oceanographic Remote Sensing.

Working Group on Remote Sensing for Oceanography of the CACRS.

Laser Bathymetry Sub-Committee of the Working Group on Oceanographic Remote Sensing.

Bolton, M.

Atlantic Tropical Experiment (GATE).

Canadian Institute of Surveying, Victoria Branch - chairman.

Canadian Institute of Surveying, Hydrographic Technical Committee - vice chairman.

Deputy Canadian Coordinator of GATE.

Fisheries and Marine Strategic Planning Committee, Pacific Region.

National Hydrographic Survey Officers' Appraisal Board.

New Research Vessel Users Design Committee - chairman.

Pacific Sub-Committee on Oceanography of CCO - alternate.

Survey Technology Advisory Committee, BCIT.

Workshop on Offshore Surveys for Mineral Resource Development.

Canadian FGGE Planning Group.

Huggett, W.S.

Nanaimo Environmental Assessment Task Force.

New Research Vessel Users Design Committee.

Sandilands, R.W.

Hydrographic Technical Committee, Canadian Institute of Surveying.

The Canadian Surveyor - associate editor (hydrography).

Survey Technology Advisory Committee, Camosun College.

Workshop Group on Offshore Surveys for Mineral Resource Development.

Board of Trustees, Maritime Museum of B.C. - chairman.

Smithers, F.R.

Public Information Group, DOE, Pacific.

Board of Trustees, Maritime Museum of B.C.

Regional Committee on Interagency Routing of Navigational Information.

Watt, J.V.

Aerial Hydrography Project Sub-Committee of Oceanography Working Group of CACRS.

Wigen, S.O.

B.C. Civil Defence Tsunami Committee.

Wills, R.

Steering Committee, Environmental Effects Study Northwestern British Columbia.

Regional Hydrographic Survey Officers' Appraisal Board - chairman.

Regional Committee on Interagency Routing of Navigational Information.

OCEAN CHEMISTRY DIVISION

Cretney, W.J.

Ph.D. Dissertation Committee - Mr. D.R. Green at UBC (Hydrocarbons).

Working Group on Laboratory Waste Disposal, Pacific Region.

Wong, C.S.

Advisory Committee - GEOSECS, Carbonate Chemistry Panel.

Advisory Committee - Chemistry, CEPEX.

Coordinating Committee on Environmental Issues, DOE, Pacific Region.

Marine Chemistry Committee, Fisheries and Marine Service, Pacific Region - chairman.

National Marine Chemistry (Standard) Group.

Ph.D. Dissertation Committee - Mr. D.R. Green at UBC (Hydrocarbons).

Ph.D. Dissertation Committee - Mr. P. Berrang at UVic (Trace Metals).

Ph.D. Supervisory Committee - Mr. A.I. Feher at UVic (Film Exchange).

OCEAN PHYSICS DIVISION

Farmer, D.M.

Babine Lake Steering Committee.

Garrett, J.F.

International Council of Scientific Unions Committee on Space Research (COSPAR), Working Group VI, Panel A (Weather and Climate).

Canadian National Committee for Scientific Committee on Oceanic Research.

Giovando, L.F.

DOE Steering Committee re environmental effects of the proposed expansion of Vancouver International Airport.

DOE Steering Committee re environmental study of Roberts Bank Development.

Working Group on Environmental Baseline Study of the Lower Fraser Valley and Fraser Estuary.

Lewis, E.L.

Associate Editor Marine Science Communications.

Panel on Ice. Arctic Oceanography Sub-Committee, Canadian Committee on Oceanography.

Sub-Committee on Snow and Ice of Committee on Geotechnical Research of National Research Council, Ottawa.

Nasmyth, P.W.

IGOSS Group of Experts on Technical Systems Design and Development and Service Requirements - chairman.

Tabata, S.

Ocean Climatic Panel of Working Group 34 of the Scientific Committee on Oceanic Research.

Thomson, R.E.

British Columbia Coordinating Climate Committee.

OCEAN ENGINEERING

Teng, K.

Pacific Region Electronic Data Processing Committee, DOE.

Canadian Information Processing Society, Victoria Section - program chairman.

Johns, R.E.

Pacific Region Electronic Data Processing Committee, DOE.

SHIP DIVISION

Geldart, E.N.

Pacific Region Resource/Survey Vessel Committee - secretary.

Working Group on Abatement of Pollution from DOE Ships - secretary.

Research and Development Contracts

		Total Amount
1.	Feasibility study of trace metal determination by isotope dilution technique using a combination of quadrupole mass spectrometer and thermo-ionic source. *Dr.G. R. Branton, Chemistry Department, University of Victoria, Victoria, B.C.*	$ 3,900
2.	Calibration of GEOSECS oceanic samples with radiocarbon content at the University of Washington Quaternary Research Radiocarbon Laboratory. *Dr. M. Stuiver, Department of Geological Science, University of Washington, Seattle, U.S.A.*	750
3.	Collection and chemical analysis of Pacific ocean water. *Case Existological Laboratories Ltd., Victoria, B.C.*	45,000
4.	Provision of technical assistance in the organization and participation in the Beaufort Sea baseline cruise and organization and execution of the beach pollutant survey. *Case Existological Laboratories Ltd., Victoria, B.C.*	23,334
5.	Application of differential pulse polarographic technique to air-sea interface studies. *Dr. P.S. Liss, School of Environmental Sciences, University of East Anglia, Norwich, England.*	7,800
6.	Radiocarbon measurements of carbonate samples. *B.C. Research, Vancouver, B.C.*	15,000
7.	Analysis of 200 samples of water for lead content by flameless atomic absorption technique. *P. Berrang, Victoria, B.C.*	1,400
8.	Installation of departmentally-owned autotitrator of the GEOSECS type. *Dr. A.E. Bainbridge, GEOSECS Operation Group, La Jolla, California, U.S.A.*	918
9.	Construction,installation and field-testing of an air-tight,water-tight dome to fit the top of the CEPEX bag system (¼ scale) for Ocean Chemistry. *Case Existological Laboratories Ltd., Victoria, B.C.*	5,000
10.	Data processing service. *SEAKEM Marine Chemistry Consultants Victoria, B.C.*	4,400
11.	Radiocarbon measurements on carbonate samples. *B.C. Research, Vancouver, B.C.*	10,000

12.	Provision of technical service for testing GC/MS system. *CHEMEX LABS. Ltd., North Vancouver, B.C.*	7,723
13.	Professional services at cost provided to Ocean Chemistry Division for biological identification and sampling of oil pollution materials in B.C. coastal waters. *Dr. T.R. Parsons, University of British Columbia, Vancouver, B.C.*	2,500
14.	Develop hulls for expendable drifting buoys. *Case Existological Laboratories Ltd., Victoria, B.C.*	20,000
15.	Feasibility and design study for a system of tracking drifting buoys in Canadian offshore waters. *Computing Devices of Canada Ltd., Ottawa, Ontario*	8,750
16.	Physical oceanographic observations and studies of water movement in Esquimalt Harbour and off Esquimalt Lagoon. *Dobrocky Seatech Ltd., Victoria, B.C.*	4,700
17.	Study of circulation of Esquimalt Harbour by tracking floats. *Dobrocky Seatech Ltd., Victoria, B.C.*	2,775
18.	Study of circulation of Patricia Bay by tracking floats. *Dobrocky Seatech Ltd., Victoria, B.C.*	2,775
19.	Develop and supply air deployable radio beacon buoy for Beaufort Sea Study. *Radio Engineering Products, Montreal, Quebec.*	31,791
20.	Conduct near-surface current survey in Beaufort Sea, including analysis and interpretation of data. *Dobrocky Seatech Ltd., Victoria, B.C.*	36,800
21.	Conduct water properties sampling and measurement program aboard CCGS Vancouver at ocean station P. *CHEMEX LABS. Ltd., North Vancouver, B.C.*	19,600
22.	Develop computerized financial accounting system for administration. *J. Inkster, Victoria, B.C.*	3,000
23.	Analyze aerial photographs and inertial navigation data for the Aerial Hydrography Project. *University of New Brunswick, Fredericton, N.B.*	7,000
24.	Conduct theoretical study of relationship between rotations obtained from the inertial navigation platform and those obtained by photogrammetric resection from aerial photographs. *Dr. S. Masry, University of New Brunswick, Fredericton, N.B.*	3,000

25.	Digitize hydrographic field sheets in support of the Chart Metrication Study. *DYNAMAP Ltd., Saskatoon, Saskatchewan.*	2,000
26.	Determination of persistence and dispersal of sewage effluents in sea water. *Dobrocky Seatech Ltd., Victoria, B.C.*	5,674
27.	Ship effluent study. *Dobrocky Seatech Ltd., Victoria, B.C.*	4,000
28.	Processing of oceanographic data derived from cruises in Juan de Fuca Strait. *Dr. M. Miyake, Institute of Oceanography, University of British Columbia,Vancouver, B.C.*	11,310
29.	Provision of consultant and advisory services to Frozen Sea Research Group on statistical methods of analysis of data on sea ice cover and topography and its application to the containment of oil by sea ice. *P.Wadhams, Victoria, B.C.*	3,600
30.	The analysis of 'quick look' and precision processed Earth Resources Technology Satellite (ERTS) data for long-range sea ice mapping applications for the Beaufort Sea Project. *J. Marko, Victoria, B.C.*	12,500
31.	Provision of professional services on modelling problems in oceanography. *Dr. N.S. Heaps, Institute of Oceanographic Sciences, Bidston, Birkenhead, England.*	2,000
32.	Modifications to the data acquisition system for the submersible, Pisces IV. *MacDonald, Dettwiler & Associates, Vancouver, B.C.*	1,300
33.	Investigation of movement of oil under sea ice. *Imperial Oil Ltd., Calgary, Alberta.*	10,000
34.	Professional services to study the physical oceanography of the southern Beaufort Sea. *Case Existological Laboratories Ltd., Victoria, B.C.*	40,862
35.	Investigation of pitch and yaw stability characteristics of Pisces IV submersible. *Dr. G. V. Parkinson, University of British Columbia, Vancouver, B.C.*	6,000

Publications - 1974

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Cretney, W.J. and C.S. Wong, 1974: Fluorescence monitoring study at ocean weather station P. *Symposium on marine pollution monitoring (Petroleum), 85-88.*

de Jong, C. and E.W. Marles, 1974: Oceanographic observations at ocean station P (50°N, 145°W), Volume 60, 12 April-7 August 1974. *Pacific Marine Science Report 74-10.*

Fujino, K., E.L. Lewis and R.G. Perkin, 1974: The freezing point of sea water at pressures up to 100 bars. *Journal of Geophysical Research, 79, 1792-1797.*

Galloway, J.L. and T. Osborn, 1974: Prototype of a self-contained tide gauge. *IEEE International Conference on Ocean 74 - Engineering in the Ocean Environment.*

Gaskin, D.G., P.W. Arnold and B.A. Blair, 1974: Phocoena phocoena. *Mammalian Species, no.42, 1-8.*

Giovando, L.F. and H.J. Hollister, 1974: Observations of seawater temperature and salinity at British Columbia shore stations 1973. *Pacific Marine Science Report 74-11.*

Gower, J.F.R., 1974: Measurement of sea surface currents using airborne doppler radar and inertial navigation systems. *The 9th International Symposium on Remote Sensing.*

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Green, D.R., C. Bawden, W.J. Cretney and C.S. Wong, 1974: The Alert Bay oil spill: a one-year study of the recovery of a contaminated bay. *Pacific Marine Science Report 74-9.*

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Lewis, E.L. and A.R. Milne, 1974: Underwater sea ice formations. *Polar Oceans Conference, SCOR/SCAR.* (in press).

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Minkley, B., C. Jackson and K. Abbott-Smith, 1974: Oceanographic observations at ocean station P (50°N, 145°W), Volume 57, May 11-September 19, 1973. *Pacific Marine Science Report 74-4.*

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Verrall, R.E., J.H. Ganton and A.R. Milne, 1974: An ice drift measurement in Western Parry Channel. *Arctic, 27, 47-52.*

Walker, G.A.H., V.L. Buchholz, D. Camp, B. Isherwood, J. Glasby, R. Coutts, A. Condal and J.F.R. Gower, 1974: A compact multichannel spectrometer for field use. *Review of Scientific Instruments, 45, 11.*

Walker, G.A.H., V.L. Buchholz, D. Camp, B. Isherwood and J.F.R. Gower, 1974: A silicon diode array spectrometer for ocean colour monitoring. *CASI Symposium on Aerospace Electronics.*

Watt, J.V., J.E. Smyth, S. Hung, D.S. Sloan, 1974: The remote sensing navigation problem and some system solutions. *First Canadian Symposium on Navigation, CASI.*

Watt, J.V., 1974: Systems of interest at C.C.R.S. *Thirteenth Annual Canadian Hydrographic Conference.* Marine Sciences Directorate, Central Region.

Watt, J.V., D.S. Sloan, N.E. Thompson, J.E. Smyth, 1974: Use of a standard airline I.N.S. for survey navigation. *Second Canadian Symposium on Remote Sensing.*

Permanent Staff - 1974

DIRECTOR GENERAL

Stewart, R.W.; B.Sc., M.Sc., (Queen's), Ph.D. (Cantab), FRSC, FRS, D.Sc. (McGill), LL.D. (Dalhousie)

DEPUTY DIRECTOR

English, W.N.; B.A. (Brit.Col.), Ph.D. (California)

MANAGEMENT SERVICES DIVISION

Todd, N.A.; B.S. (Glasgow), M.A. (Carleton); Chief of Division

Blair, B.A.; B.Sc., M.Sc. (Guelph)
* Chamberlain, K.S.
Craton, M.I.K.
Crouch, R.W.
* Crowell, D.B.
Doyle, D.A.
Egan, L.L.
Firth, C.
Foote, S.B.
* Foreman, I.
* Gleadow, P.M.
* Gough, D.C.
Gravel, J.N.J.
Hall, E.J.
* Hartley, A.M.
Hogg, W.
Lohse, P.O.
* McIntosh, J.Y.
MacKenzie, R.M.
Martyn, B.T.
Oswald, P.E.
Parsons, J.E.
* Pimlott, S.K.
Sabourin, J.T.
Smith, D.C.
* Stewart, A.M.
* Thirkell, L.E.
Thomas, C.D.
Thomson, L.S.; B.A. (Saskatchewan) B.L.S. (Brit.Col.)
Van Dusen, T.S.
Wakefield, L.M.

* Left during 1974

HYDROGRAPHIC DIVISION

Bolton, M.; Regional Hydrographer

Ages, A.B.; B.A.Sc., M.A.Sc., (Brit.Col.), P.Eng.
Ames, S.E.
Anderson, N.M.; B.Sc.(Victoria) Dip.AIT
Bath, J.F.; Master, F.G. (Deceased)
Bell, R.D.
Bennett, K.M.
Brown, R.E.
Browning, P.C.
Campbell, I.J.; Dip.BCIT
Chivas, J.W.; Master, F.G.
Clark, D.J.
* Clarke, E.B.
Coldham, F.A.
Coldwell, J.H.
* Cooke, G.L.; Dip.NSIT
Cooke, R.A.
Coulter, E.M.
Curran, T.A.; B.A.Sc.(EE) (Brit. Col.), P.Eng.
Czotter, K.L.; Dip.BCIT
Dobson, D.G.
Dorosh, L.W.; Dip.BCIT
* Dyas, T.; RN Trade Cert.
Eaton, G.H.; Dip.BCIT
Fujino, N.S.; Dip.BCIT
Galloway, J.L.; B.A.Sc.(EE), M.A.Sc.(EE) (Brit. Col.), P.Eng.
Gregson, D.J.; Dip.BCIT
Harris, W.J.
Hermiston, F.V.
* Highton, K.; Dip.BCIT
Hinds, E.W.; Dip.BCIT
Hlina, R.C.; Dip.BCIT
Holman, K.R.
Huggett, W.S.; Master, F.G.
Johnson, R.W.
Jones, T.; Master, F.G.
Korhonen, R.K.
Landry, L.P.; B.Sc.(Brit.Col.), Dip.BCIT
Larkin, J.B.; B.Sc.(P.E.I.) .
* Lee, P.O.; Dip.BCIT
Loshiavo, R.; Dip.BCIT
Lusk, B.M.; Master, 350 T
Lyon, A.G.
* McIntosh, C.G.; Master, F.G.
Mortimer, A.R.; Master, F.G.
Muse, R.A.; Trade Cert.CAF
Nast, C.J.
O'Connor, A.D.
Osborne, M.; Cert.(T.I.)
Patton, M.M.
Philp, A.R.
Pierce, R.A.
Plume, T.C.
Popejoy, R.D.
Rapatz, W.J.; B.Sc.(Victoria)
Raymond, A.R.; Dip.Algonquin College
Richardson, G.E.
* Rogers, G.W.
Ryan, C.F.; Dip.RRE (England)
Sandilands, R.W.; Lt.RN (Retired)
Smithers, F.R.
Stephenson, F.E.; B.Sc.(Victoria)
Tamasi, C.R.; Dip.BCIT
Taylor, M.S.
Taylor, W.R.; Dip.RCC
Thompson, L.G.
* Vosburgh, J.A.; Dip.BCIT
Watt, B.M.
Watt, J.V.; B.A.Sc.(EE) (Brit.Col.), P.Eng.
Wigen, S.O.; B.A.Sc.(Brit.Col.), P.Eng.
Wills, R.; Master Mariner, F.G.
Woods, M.V.; Dip.BCIT
* Yee, P.Y.; Dip.BCIT
Young, V.N.

* Left during 1974

OCEAN CHEMISTRY DIVISION

Wong, C.S.; B.Sc., M.Sc. (Hong Kong), Ph.D. (Scripps), Dip.Mar.Sc. (UNESCO), MCIC, FRIC; Chief of Division

Bellegay, R.D.; Dip.NAIT, Ass.Deg.in Oceanography (Shoreline Comm. College, Seattle)
Cornford, A.B.; B.Sc.(McMaster), Ph.D.(Brit.Col.)
Cretney, W.J.; B.Sc., Ph.D.(Brit.Col.)
Jackson, C.M.; B.Sc.(Victoria)
Johnson, W.K.; Dip.BCIT
* Pannekoek, W.J.; B.Sc.(Alberta)

COMPUTING SERVICES

Butcher, J.W.; B.Sc.(Victoria), M.Sc.(Toronto)
Douglas, A.N.; B.Sc.(Victoria)
Johns, R.E.; B.Sc.(Victoria), M.Sc.(Brit.Col.)
Morgan, C.G.; B.Sc., M.Sc.(Alberta)
Richards, P.J.; B.Sc.(Brit.Col.)
Smith, D.B.; B.Sc.(Victoria)
Teng, K.; B.A.Sc., M.A.(Brit.Col.)
Woollard, A.L.; B.Sc.(Victoria)

OCEAN PHYSICS DIVISION

Nasmyth, P.W.; B.A.Sc., M.A., Ph.D.(Brit.Col); Chief of Division

* Abbott-Smith, K.B.
Bell, W.H.; B.A.Sc.(Brit.Col), M.Sc.(Hawaii)
Bigham, R.H.
Bradbury, J.D.
Chase, G.W.; Dip.BCIT
Crean, P.B.; B.Sc.(Dublin), M.A.Sc.(Toronto), Ph.D.(Liverpool)
de Jong, C.
Farmer, D.M.; B.Com., M.Sc.(McGill), Ph.D.(Brit.Col.)
* Forbes, R.E.
* Gantzer, K.A.
Gargett, A.E.; B.Sc.(Manitoba), Ph.D.(Brit.Col.)
Garrett, J.F.; B.A.(Harvard), Ph.D.(Brit.Col.)
Giovando, L.F.; B.A., M.A., Ph.D.(Brit.Col.)
Gower, J.F.R.; B.A., M.A., Ph.D.(Cantab)
Henry, R.F.; B.Sc.(Edinburgh), Ph.D.(Cantab)
Herlinveaux, R.H.
Kamitakahara, G.R.
Koppel, A.W.
Kuwahara, L.S.C.
Lake, R.A.; B.Sc.(Brit.Col.), M.Sc.(Washington)
Lewis, E.L.; B.Sc., M.Sc., Ph.D.(London)
Marles, E.W.; B.Sc.(Victoria)

Meikle, J.H.
Milne, A.R.; B.A.Sc.(Toronto), M.Sc.(McGill)
Minkley, B.G.; Dip.BCIT
Moody, A.E.
Moorhouse, S.W.
Perkin, R.G.; B.A.Sc., M.Sc.(Brit.Col.)
Richards, D.L.
Sieberg, D.G.
Spearing, L.A.F.
Stickland, J.A.
Sudar, R.B.; B.A.Sc.(Toronto)
* Sutherland, J.A.
Tabata, S.; B.A., M.A.(Brit.Col.), D.Sc.(Tokyo)
Teichrob, R.C.; Dip.BCIT
Thomson, R.E.; B.Sc., Ph.D.(Brit.Col.)
Walker, E.R.; B.Sc.(Manitoba), M.A.(Toronto), Ph.D.(McGill)
Wallace, J.S.

* Left during 1974

SHIP DIVISION

Geldart, E.N.	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Regional Marine Superintendent.
Green, F.S.	Master Mariner; Assistant Marine Superintendent (Deck).
Marr, D.	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Assistant Marine Superintendent (Engineering).
Keene, R.W.	Master, F.G. (X); Relief Master.
Pride, L.G.	Engineer 2nd Class Motor; Relief Engineer.

CSS PARIZEAU

Chamberlain, A.G.	Master, F.G.; Master
Fisher, E.G.	Master, F.G.; 1st Officer
* Lewis, B.J.	2nd Mate, F.G.; 2nd Officer
Christie, J.N.	Radio Certificate; W/O
Clarke, L.E.	Supply Officer
Aaron, B.N.	Engineer 1st Class Combined; Chief Engineer
Delany, W.G.	Engineer 2nd Class Motor; Senior Engineer
Kyle, R.G.	Engineer 2nd Class Motor; 1st Engineer
McKay, M.J.	Engineer 4th Class Motor; 2nd Engineer

CSS WM.J.STEWART

Sjoholm, K.J.	Master, F.G.; Master
Easson, R.J.	Master, F.G.; 1st Officer
Barboza, C.S.	Mate, F.G.; 2nd Officer
Wheeler, M.G.	Mate, H.T.; 3rd Officer
Palmer, S.	Supply Officer
Henderson, J.D.	Engineer 2nd Class Steam; Chief Engineer
Gibson, R.B.	Engineer 3rd Class Steam; Senior Engineer
Bateman, S.P.	Engineer 3rd Class Combined; 1st Engineer
Conway, A.	Engineer 4th Class Combined; 2nd Engineer

CSS VECTOR

Marston, J.C.	Master, F.G.; Master
Oudshoorn, A.B.	Master, H.T.; 1st Officer
Bishop, S.O.	Mate, H.T.; 2nd Officer
Clouston, G.W.	Engineer 3rd Class Motor; Chief Engineer
Storer, T.H.	Engineer 3rd Class Motor; 1st Engineer
Pearson, R.	Engineer 4th Class Motor; 2nd Engineer

CSS RICHARDSON

* McIntyre, C.M.	Master, 350 T.; Master
Henderson, J.N.	Engineer 4th Class Motor; Chief Engineer

CFAV LAYMORE

Dyer, M.J.	Master
Doherty, H.R.	Chief Engineer

MV RADIUM EXPRESS (Charter)

O'Sullivan, J.	Master
Butler, W.	Chief Engineer

MV PANDORA II (Charter)

Dickinson, R.	Master
Ward, R.	Chief Engineer

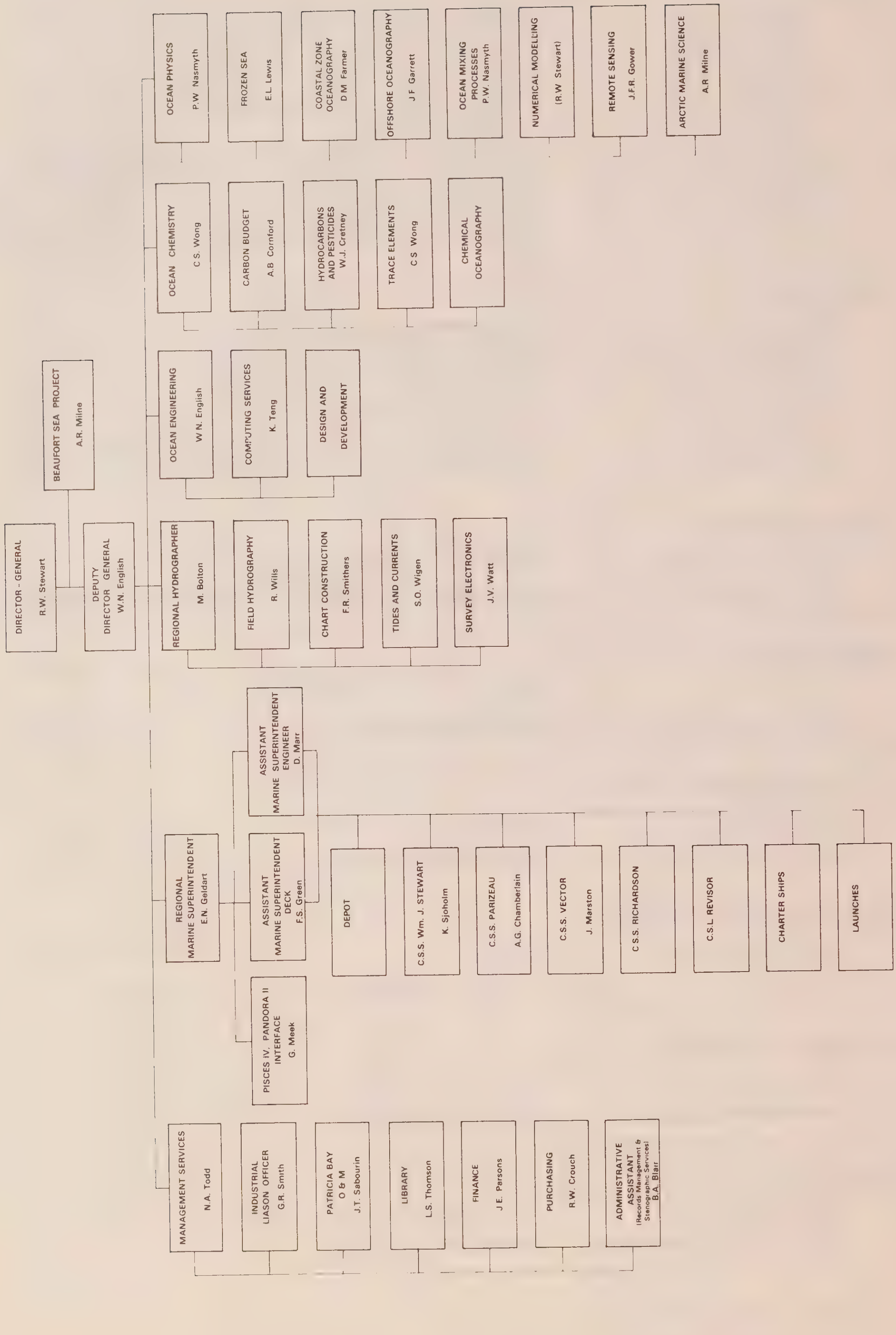
MV THETA (Charter)

Maro, K.	Master
Johannsen, A.	Chief Engineer

PISCES IV

Meek, Maj.G.R.	Operations Officer (DND)
Legallais, Capt.P.S.	Chief Pilot (DND)

* Left during 1974


DIRECTOR - GENERAL
R.W. Stewart
BEAUFORT SEA PROJECT
A.R. Milne
DEPUTY DIRECTOR GENERAL
W.N. English
OCEAN PHYSICS
P.W. Nasmyth
FROZEN SEA
E.L. Lewis
COASTAL ZONE OCEANOGRAPHY
D.M. Farmer
OFFSHORE OCEANOGRAPHY
J.F. Garrett
OCEAN MIXING PROCESSES
P.W. Nasmyth
NUMERICAL MODELLING
(R.W. Stewart)
REMOTE SENSING
J.F.R. Gower
ARCTIC MARINE SCIENCE
A.R. Milne
OCEAN CHEMISTRY
C.S. Wong
CARBON BUDGET
A.B. Cornford
HYDROCARBONS AND PESTICIDES
W.J. Cretney
TRACE ELEMENTS
C.S. Wong
CHEMICAL OCEANOGRAPHY
OCEAN ENGINEERING
W.N. English
COMPUTING SERVICES
K. Teng
DESIGN AND DEVELOPMENT
REGIONAL HYDROGRAPHER
M. Bolton
FIELD HYDROGRAPHY
R. Wills
CHART CONSTRUCTION
F.R. Smithers
TIDES AND CURRENTS
S.O. Wigen
SURVEY ELECTRONICS
J.V. Watt
REGIONAL MARINE SUPERINTENDENT
E.N. Geldart
ASSISTANT MARINE SUPERINTENDENT ENGINEER
D. Marr
ASSISTANT MARINE SUPERINTENDENT DECK
F.S. Green
PISCES IV, PANDORA II INTERFACE
G. Meek
DEPOT
C.S.S. Wm. J. STEWART
K. Sjoholm
C.S.S. PARIZEAU
A.G. Chamberlain
C.S.S. VECTOR
J. Marston
C.S.S. RICHARDSON
C.S.L. REVISOR
CHARTER SHIPS
LAUNCHES
MANAGEMENT SERVICES
N.A. Todd
INDUSTRIAL LIASON OFFICER
G.R. Smith
PATRICIA BAY O & M
J.T. Sabourin
LIBRARY
L.S. Thomson
FINANCE
J.E. Parsons
PURCHASING
R.W. Crouch
ADMINISTRATIVE ASSISTANT (Records Management & Stenographic Services)
B.A. Blair

Portion of chart 3481 showing fathoms and feet presentation, above, and new metric format.

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT – 1975

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY
Victoria, B.C.

Please address inquiries to:

Environment Canada
The Institute of Ocean Sciences
1230 Government Street
Victoria, B.C. V8W 1Y4
CANADA

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT 1975

The Institute Under Construction

December 1975

Victoria, B.C. March, 1976

Charter ships Pandora II, with the submersible Pisces IV, and Theta left Victoria July 23 for the 1975 Arctic season. Map shows their route to Halifax, where Theta went off charter, and Pandora's return trip through the Panama Canal to Victoria.

Introduction

1975 has been a year which has more than usually taxed our ability to maintain flexibility in the face of the unexpected. It has seen more than its share of disappointments. Most of these disappointments originate in the downturn of the world's and of Canada's economy, which led the Government of Canada to institute a drastic curtailment of programs, commencing in the summer of 1975. Announced programs such as the Georgia Strait Project were postponed into an indefinite future. Programs being planned, such as the cooperative program with the United States with respect to the projected large increase in tanker traffic on the west coast and in Juan de Fuca and Georgia Straits, were reduced to pale ghosts of what had been anticipated. Because the slowdown in the west coast economy had reduced staff turnover, particularly in ships, the cutback in allowable man-year utilization which was announced in late summer caught us with a maximum number of people on staff. Only very drastic measures, including the shortening of the hydrographic field season and the laying up of the CSS William J. Stewart, enabled us to effect the necessary curtailments. These cuts went deep into the bone and muscle of our organization.

On the other hand, the Department has agreed to keep the construction of our Institute facilities at Patricia Bay high in its priorities. Although costs have escalated, as have costs of all construction in Canada, the project has kept close to schedule. At the end of the year the dock was approaching completion, and it is expected that that and the shop facilities associated with it will be in operation in 1976. The rest of the structure is taking form, and progress is visible from week to week. God, the unions and Treasury Board willing, we will have our much needed facilities in 1978.

The effect of budget cuts was by no means the only external influence which impacted on us during 1975. For example, in February two tank cars filled with pressurized liquid chlorine were lost at sea from a barge on the eastern side of Georgia Strait. This event produced an emergency of some magnitude. It was not known where exactly the tank cars had been lost, but it was known that if they became ruptured in shallow water there was a serious danger of the escape of large quantitities of gaseous chlorine which would endanger life. A crash operation was mounted by the Hydrographic Division, at the request of the Ministry of Transport, to try to locate the tanks if they were in shallow water.

At the same time an examination was made by Ocean Chemistry to determine the behaviour to be expected if the chlorine leaked from the tanks at sufficient depth that it might be expected to remain liquid. This study left some confidence that in deep water the chlorine would produce no

hazard to humans. Repeated sweeps by our vessels, and by contractors to MOT supervised by our hydrographers, revealed many targets. All of these were methodically eliminated, a good number after examination and identification by our submersible, Pisces IV, which proved invaluable in this operation. The tank cars themselves were not found, but we were able to show that there was a very low probability that they were in shallow water.

This 'chlorine tank caper' was merely the most spectacular of a number of events occurring during the year which deflected us temporarily from pursuing long established goals.

As important as any of our other activities in 1975 was the culmination of the Beaufort Sea Project, which was managed from our offices in Victoria by Mr. Allan Milne, Head of our Arctic Marine group. It required the coordination and focussing of several dozen studies carried out by groups based at various locations across the country, most carrying out field work within the Beaufort Sea area. Although reports from many of the individual projects were not complete by the end of 1975, the basic objective of developing a preliminary environmental assessment document within 1975 was achieved. The document has been very widely circulated and is a key input to the Cabinet decision which will be made early in 1976 concerning whether or not exploratory drilling will proceed in 1976.

Not only was the Beaufort Sea project managed from OAS Pacific, but every division played some role in the project. Often these roles interlocked. For example, the Tidal and Current Survey Section of the Hydrographic Division obtained a wealth of water level data in the Beaufort Sea which was used in the construction of a numerical model of storm surges by the Ocean Physics Division. The Beaufort Sea Project should serve as a revealing model of a major environmental 'crash' program. Despite generally uncooperative weather and ice conditions, it was probably as successful as anyone had any reason to expect. However such crash programs have many inherent limitations not the least of which is the fact that no year is ever quite like any other year and a program lasting for only two years cannot hope to present a full environmental picture. Nevertheless those responsible for and deeply engaged in the Beaufort Sea Project have been left with a considerable sense of well-deserved satisfaction for a difficult job well done.

As always, it is these extraordinary events which attract attention. Again as always the work done by people systematically going about their regular business effectively and conscientiously is no less a part of our activity and is no less important. This annual report documents our efforts and accomplishments of both kinds.

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

The major field efforts were devoted to a modern survey of Juan de Fuca Strait and its seaward approaches in anticipation of the forthcoming Alaskan tanker traffic. As a consequence (probably fortunate in view of extremely heavy ice conditions) no Western Arctic programs were planned.

A new chart format, emphasizing depth contours, was designed through a cooperative effort of Development and Chart Construction personnel. This format, which has received general acceptance by the maritime community, will be the base for the production of new navigational charts featuring metric units. Paralleling the transfer of additional man-years from headquarters was the transfer of chart maintenance responsibility for Pacific coast charts to the region.

In September, Regional Tidal Superintendent S.O. Wigen was seconded to the International Tsunami Information Centre as Associate Director for a one year period. Activities directed towards the Beaufort Sea project were continued, and data collected will enhance our navigational knowledge of the area.

In anticipation of further man power and monetary restraints in the next fiscal year, it is appropriate to review and, if necessary, revise and modify the various regional hydrographic programs. Contingency plans are being developed which may cause significant adjustments in 1976.

Sounding at speed on the Mackenzie River

R. Wills - Regional Field Superintendent

F. A. Coldham
K. L. Czotter
G. H. Eaton
N. S. Fujino
*R. C. Hlina
J. B. Larkin
B. M. Lusk
R. I. May
P. R. Milner
A. R. Mortimer
A. D. O'Connor
R. A. Pierce
R. D. Popejoy
M. L. Preece
A. R. Raymond
G. E. Richardson
R. W. Sandilands
R. U. Shoenrank
C. R. Tamasi
J. G. Wanamaker
D. J. Wood
M. V. Woods

*Left during 1975

This section is responsible for all hydrographic field operations and includes Hydrographic Development and Sailing Directions.

The field season for major parties began in mid-April with the principal field effort being concentrated on the west coast of Vancouver Island from the Strait of Juan de Fuca north to the Brooks Peninsula.

CSS Parizeau, with B. M. Lusk as hydrographer-in-charge, carried out hydrographic and geophysical surveys (gravity and magnetic) from the Canada - United States boundary off the Strait of Juan de Fuca north to the Brooks Peninsula and out over the 400 m line. For logistic support she was fitted with a temporary landing pad forward for an Alouette helicopter.

CSS WM. J. Stewart, with G. E. Richardson as hydrographer-in-charge, surveyed the Canadian portion of the Strait of Juan de Fuca west from Otter Point and continued north to Barkley Sound. The survey of Barkley Sound was continued from 1974 and included a large-scale survey of Bamfield and Grappler Inlets. Work was begun on a large-scale survey of Ucluelet Inlet.

This party also spent a brief period working on the Fraser River delta front between the Roberts Bank superport and the Tsawwassen ferry terminal to determine what changes may be occuring there.

The ship was withdrawn from the field at the end of September, three weeks ahead of schedule, due to man-year and financial constraints.

On the Mackenzie River a party on board the chartered vessel Radium Express, with A. D. O'Connor as hydrographer-in-charge, conducted the annual revisory surveys. In addition, surveys for five new charts were carried out on the river between Head of the Line and Lousy Point, thus completing the new surveys of this section. Reconnaissance surveys were made of the Liard-Fort Nelson river system and the Lower Great Bear River.

Several times during the year extensive support was given to the Ministry of Transport search for four chlorine tank cars lost in the Malaspina Strait area.

Debris washed down from the banks is a navigational hazard on the Liard River

Sailing Directions

*T. L. Jones - Head
J. W. Chivas

*Retired during 1975

+R. W. Sandilands - Acting Head
L. M. Wakefield

+Rotational staff

The sixth edition of B.C. Sailing Directions (North Portion), Volume II was received from the printers in February.

In October the first edition of the Small Craft Guide, Volume II, was published. This new publication, written with recreational boaters in mind, covers the mainland coast from Boundary Bay to Cortes Island and complements Volume I, which gives coverage of the Vancouver Island coast from Sooke to Nanamimo, including the Gulf Islands.

It is planned to extend coverage for the third edition of the Small Craft Guide, Volume I, from Alberni to Sooke, including all of Barkley Sound, and from Nanaimo to Campbell River, thus giving complete small craft sailing directions and details of shore facilities for all southern B.C. waters. The manuscript for these extensions has been completed and is presently being put on tape at the office of the editor in Ottawa. Publication is scheduled for 1976.

The manuscript for the tenth edition of B.C. Sailing directions, Volume I, has been updated and is expected to be ready for publication in mid-1976.

A gazetteer of local place names is being compiled. Preliminary data compiled have already proven to be of value to Air Sea Rescue authorities on several occasions. This gazetteer will be purely an internal listing for such purposes.

No field work was undertaken by this unit in 1975.

Hydrographic Development

*N. M. Anderson - Head
+N. S. Fujino
+A. R. Mortimer
+C. R. Tamasi

*Transferred to headquarters
+Rotational staff

Development Group activities were focused on four major projects.

A version of the University of Washington FOCAL was adapted, under contract, to the Haaps configuratin of the PDP8/e computer and the new version implemented in the processing of Haaps data collected aboard CSS Parizeau this season. Following a hectic introductory period which was complicated by computer hardware malfunctions, this new version of FOCAL operated successfully.

Field work continued on long range tests of microwave positioning systems and a report is to be published this winter.

A study has been made of the requirements of the Hydrographic Service, Pacific Region, for instrumentation, chain callibration and chart latticing in connection with Loran C, scheduled to be on the air on the west coast by January 1977.

The Aerial Hydrography Project is progressing slowly but favourably with significant input from the Canada Centre for Remote Sensing. Flight tests conducted this summer have provided data which appears to be quite reliable. Horizontal and vertical control problems have become apparent in the test area and further evaluation of the data is impossible until these are solved. An evaluation of the new Kodak water penetration

film has indicated that there is no improvement over standard colour film. The evaluation cannot be considered rigorous as it was not possible to exercise direct control of the camera exposure during the tests.

Additional activities included input into the specifications for a Portable Hydrographic Acquisition System (PHAS) and into a new Fortran program to process Haaps data.

Tidal and Current Survey Section

S.O. Wigen - Regional Tidal Superintendent

This section conducted major field programs in the Pacific and the Western Arctic. Hydrodynamic surveys continued in Juan de Fuca Strait and in the approaches to and in Burrard Inlet. Tides and bottom currents were monitored as part of the Beaufort Sea Project. Vertical control for hydrographic charting of the Mackenzie-Athabasca waterway was again provided to hydrographers. Considerable time was spent by all units in providing information to the general public, engineering consulting firms, universities and government agencies.

On September 1 Mr. S. O. Wigen left for Honolulu, Hawaii, to take up a post as Associate Director of the International Tsunami Information Centre for a period of one year. Mr. W. Rapatz will be the acting regional tidal superintendent during Mr. Wigen's absence.

Hydraulic Research

A.B. Ages - in charge
*A. Harrison
K. Lee (CELL)
A. Woollard (Computing Services)

*Left 1975

A two-dimensional numerical model of Burrard Inlet was developed and calibration of this model was begun by extensive measurements of tides, currents, winds, temperatures and salinities. Measurement of surface currents in the approaches to Burrard Inlet was done with the co-operation of the Institute of Oceanography, UBC. Simultaneous tidal observations were obtained at Indian Arm and Port Moody.

A provisional computer program was developed to predict the movement of oil spills in the Straits of Juan de Fuca and Georgia. The program parameters are the surface currents of the two basins, the spreading velocity of the type of oil spilled, and the winds at the time of the accident. Information was provided to government agencies and private industry on problems concerning marine pollution and tidal hydraulics. Especially useful were tidal computations of the Fraser River made with the aid of the numerical model developed earlier.

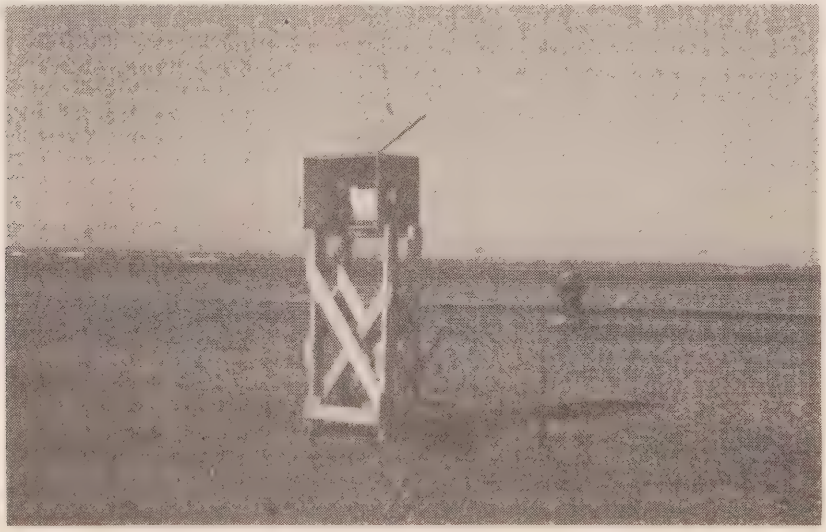
Current Surveys

*K. Cote
A.N. Douglas
W. J. Harris
F. V. Hermiston
W.S. Huggett (in charge)
*M. Petch
W. Tario
M. J. Woodward

*Left 1975

The main effort of Current Surveys was again directed towards the Beaufort Sea Project. In May, eight current meters and tide gauge arrays were deployed in the Beaufort Sea with the aid of a helicopter, and seven of these arrays were recovered in August from the M.V. Theta. Three of the arrays were re-deployed and two were recovered in September. The two arrays deployed north of Herschel Island were not recovered because of 10/10 ice coverage in the area from the end of August onwards. The first array put down in this area may have been damaged by ice, or had a fault develop in the acoustic release gear. A report on off-shore tides and bottom currents was written and will be included in the Beaufort Sea report.

A major tide and current survey was carried out in the Strait of Juan de Fuca from May to July. Twelve instrument arrays consisting of eight tide gauges and nine current meters were moored across the Strait from Sheringham Point to Pillar Point, Washington. The purpose of this survey is to study the current flowing through the Strait and its relationship to the difference in bottom pressures across the Strait. Analysis of the data and interpretation of the results are presently being carried out by D. Fissel under contract.



Land-locked tide gauge at Kay Point in the Yukon was almost completely submerged during storm surge in the southern Beaufort Sea

Two current meter arrays were deployed off the west coast of Vancouver Island in conjunction with Dr. A. Huyer's study of "Alongshore Coherence at Low Frequencies in Currents Observed over the Continental Shelf." All were recovered in April. A summary of the data has been presented and a more detailed study of the data is in progress.

Tide and current meters were deployed in the approaches to Burrard Inlet to provide data for the Burrard Inlet numerical model, and for the study of internal gravity waves and longshore currents.

Tidal Survey

R. E. Brown
C. C. Carracedo
D. E. Hilder
*W. Lane
J. J. Manson
L. E. Ponse
A. J. Smedley
W. J. Rapatz - in charge until September 30
C. E. Stenning - on contract
F. E. Stephenson - in charge from October 1

*left in 1975

This unit operated nine temporary gauging stations on the coast of British Columbia. Data from these stations are used to advance knowledge of the tidal progressions on the coast.

Two Aanderaa TG1A gauges installed at Neah Bay, Washington, were recovered in 1975. Analysis of records indicates that the float gauge operated by National Ocean Survey in Neah Bay accurately represents the tides in the Strait of Juan de Fuca.

Two tide gauges were recovered from seamounts in the North Pacific in 1975. An Aanderaa tide gauge on Union Seamount was recovered with 114 days of continuous records and a tide gauge designed for the Section by IOUBC was recovered from Surveyor Seamount with 346 days of continuous record.

Ten tide gauges were operated along the shores of the Beaufort Sea during the summer. Two major storm surges occurred during this observation period. These are the most thoroughly observed storm surges in the Canadian Arctic to date, and the records provide much needed information for the numerical model of the area.

Several water level gauges were operated in the Mackenzie River and its tributaries to supplement water level information from permanent gauges for hydrographic surveys of the river.

Tidal records from all permanent and temporary gauging stations were processed and sent to the Marine Environmental Data Service for permanent storage.

Chart Construction Section

F. R. Smithers - Regional Chart Superintendent

K. Bennett
R. Bell
P. Browning
P. Buckley
D. Clark
E. Coulter
D. Dobson
M. Farmer
K. Holman
R. Korhonen
A. Lyon
C. Nast
M. Patton
K. Peterson
A. Philp
L. Pickell
T. Plume
M. Taylor
L. Thompson
J. Underwood
J. Unti
K. Vaino
B. Watt
V. Young
W. Young

This section is responsible for the compilation, drafting, photo-mechanical processing for printing, correction and distribution of all Pacific Coast nautical charts.

Four new charts were constructed and printed at Evergreen Press in Vancouver during 1975. Several charts being compiled were totally reconstructed in order to present them in metric, bilingual format conforming to present Canadian Hydrographic Service policy. As all existing charts will eventually be redrawn to conform to these requirements, plus a new standard paper size, a rescheming of all Pacific Region charts is underway.

Responsibility for maintenance of all the new editions and reprints has been transferred to this office, and all drafting and reprographics for printing are made by the Section before submission for outside contract printing. The number of charts printed will increase from 10 in 1975 to 43 in 1976.

The correction and distribution unit moved to 33 Dallas Road in September to accommodate the constantly increasing volume of publications. The chart corrections unit made 1,905,061 hand amendments. The chart distribution unit processed and shipped 165,339 charts and 62,241 publications. This unit also inspected 21 dealers to ensure that the terms of reference were maintained. As a result 10 dealerships were cancelled and seven new dealerships established.

The graphic arts unit constructed a display using the prototype of metric chart 3481M as a theme. This booth was set up and staffed at the Vancouver International Boat and Sport Show. Copies of the chart and questionnaires were distributed, and two senior cartographers answered questions on the metrication of charts.

A graphic display was also constructed depicting the steps involved in the construction of a nautical chart. This was used for a lecture given at the national convention of the Canadian Power Boat Squadron in Vancouver. It is being used as a permanent display for guided tours of the Chart Construction Section and can be updated as methods of chart construction change.

The MAREP program (a marine reporting system with the Canadian Power Boat Squadron) has been very successful on the west coast with the submission of 250 reports during the year. These reports were directly responsible for the promulgation of eight Notices to Mariners.

Survey Electronics Section

J. V. Watt - Head

The Survey Electronics Section provides electronics engineering and technical support for survey, research and ship operations in the Pacific Region. A significant increase in demands for engineering assistance combined with maintenance and field support kept the Section very busy during the year.

Technical Support Group

W. R. Taylor - Head
R. A. Cooke (with FSRG)
L. W. Dorosh
D. J. Gregson
E. W. Hinds
R. Loschiavo
R. A. Muse
M. Osborne
C. F. Ryan
T. J. Soutar

Activities of the Technical Support Group involved field support for survey parties aboard the Institute ships Wm. J. Stewart and Parizeau and the charter vessel MV Radium Express, in addition to general electronics maintenance duties for Hydrographic and Ship divisions.

A major effort was expended in upgrading and replacing radiotelephone equipment aboard the charter vessels Theta and Pandora II in preparation for their arctic operations.

Scheduling improvements and revisions in preventive maintenance measures before the 1975 field season resulted in a significant reduction of equipment failures. Maintenance schedules for permanent shipboard electronic installations were revised, and new schedules will be in effect during 1976.

Engineering Support Group

T. A. Curran
J. L. Galloway

Engineering efforts in support of the Hydrographic Development Group and in hydrography-oriented projects initiated by the section have led to favourable progress on the Aerial Hydrography Project, the contract for the portable hydrographic acquisition system (PHAS), and to the development of a new Fortran-based software package for processing Haaps data.

Projects such as the redesign of the CMDR current meter to incorporate C-MOS technology and continued support of the 'UBC' tide gauge, being conducted for Tidal Survey, are progressing well.

Data from a single channel satellite navigation receiver were collected, tabulated and forwarded to the Navigation Group of Bedford Institute of Oceanography at their request. A project to plot Haaps data on a line printer/plotter was initiated, conducted and completed under contract, with the results going to the Bedford Hydrographic Development Group.

Support for oceanographic activities involved interface electronics for a drifting buoy experiment using a satellite data link, systems design and modification for a computer-based CTD system, development of a combination tape translator and computer interface for Aanderaa data tapes, redesign of an electronic bathythermograph, and the completion of a combination Memodyne/Geodyne data tape reader and computer interface.

Landing pad was constructed on CSS Parizeau for helicopter support during hydrographic survey off West Coast of Vancouver Island

OCEAN CHEMISTRY DIVISION

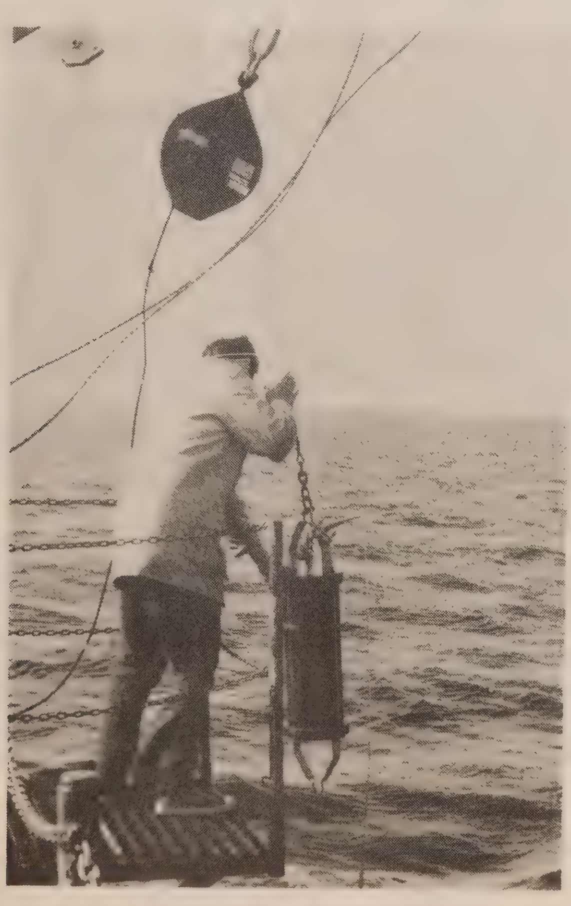
C. S. Wong - Chief of Division

Marine Hydrocarbons Section

W. J. Cretney - Head

P. A. Christensen (NRC Postdoctoral Fellow) - GC/MS System
W. J. Cretney - Hydrocarbon analysis, clean-room techniques
D. R. Green (Visiting Student, UBC) - Pelagic tar
R. W. Macdonald (NRC Postdoctoral Fellow to July 30, 1975) - LMW Hydrocarbon gases
C. S. Wong - Environmental effects.

The objective of the program is to understand the occurrence, pathways and fate of hydrocarbons (natural, petroleum-based and halogenated) in the marine environment. The contaminant levels of these substances in the ocean are poorly known. In addition, analytical and sampling techniques for investigating petroleum hydrocarbons in sea water are still being developed. The Division has been concentrating on contaminant-free sampling and laboratory environment in order to ensure the integrity of the results.



A contaminant free 'Blumer' sampler for LMW and PAH hydrocarbon sampling in sea water.

In field sampling, sea water samples for hydrocarbons work were mainly collected by a 5-liter 'Blumer' sampler. This consisted of a 5-liter glass bottle, evacuated and sealed by a disc which could be opened at a desired depth by a pressure activated valve. Thus the chance of contamination by the surface microlayer when the sampler was lowered would be minimized.

A portable clean laboratory, eight feet wide by sixteen feet long by seven feet high, was fitted with a carbon filter to remove hydrocarbon fumes from the ship at the intake of air into the laboratory environment. This laboratory has three compartments: a 'clean' area near the entrance for preliminary work-up, an 'air-shower' compartment to remove dust and particulate contaminants from the operator, and a superclean working area for sample preparation and analysis. It was used with success in the Beaufort Sea on MV Pandora II. This hydrocarbon clean laboratory is the first of its kind for shipboard contaminant-free analysis and sample work-up.

A Finnigan 3300 E gas chromatograph/mass spectrometer system capable of a mass range of 10-1000 amu and a sensitivity of 3×10^{-11} g/sec for cholesterol was applied to the detection of polyaromatic compounds in marine environmental samples. This GC/MS system was also interfaced with a PDP-11 mini-computer to improve the sensitivity of measurements. Clean-laboratory techniques for extraction of polyaromatics from biological tissues and marine sediments are being applied to Beaufort Sea samples. A technique using fluorescence and high speed liquid chromatography (FS-HPLC) was being applied to monitor total polyaromatic hydrocarbons at ocean weather station P, along line P, in Saanich Inlet and nearshore waters in Victoria.

Trace Metals Section

C. S. Wong - Head

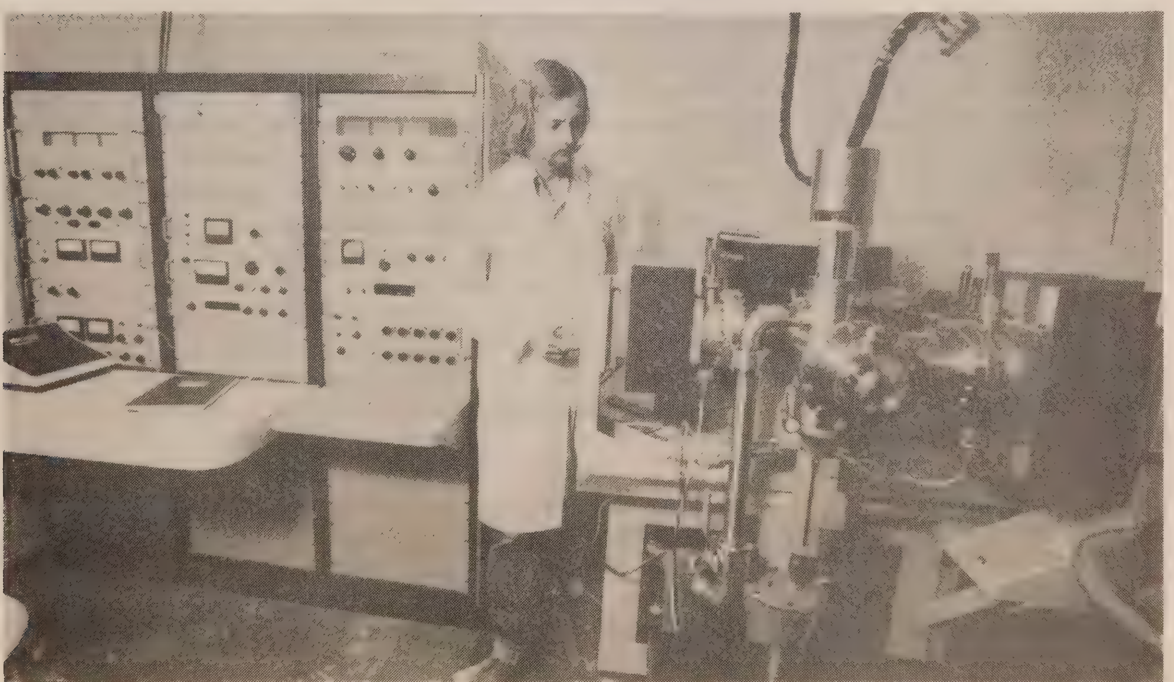
C. S. Wong - Lead, mercury in the marine environment, clean room techniques
K. Kremling (Visiting Scientist, University of Kiel) - cadmium in sea water
J. Piuze (NRC Postdoctoral Fellow) - Anodic stripping technique, cadmium
W. K. Johnson
E. Matsumoto (NRC Postdoctoral Fellow) - Pb-210 dating, marine sediments

The main objective of the Section is to assess the natural and anthropogenic inputs of physiologically significant metals into the marine environment, with special reference to coastal and open ocean waters. However, in contrast to marine hydrocarbons of petroleum origin, natural inputs of trace metals may exceed the anthropogenic ones and the assessment of pollution impact is difficult. As in the case of petroleum-based hydrocarbons, trace metals measurements require substantial care in sampling, preservation of sample integrity and contaminant-free analysis in clean rooms. One shore clean room and one shipboard clean laboratory with carbon filtered air at intake were available. These clean rooms are among the few in the world for trace environmental studies and the shipboard laboratory was the first of its kind.

Intercalibration studies form an important part of low-level trace measurements, in order to establish confidence in the data collected. This Section participated in the California Institute of Technology intercalibration on lead in sea water, as part of an IDOE study, and in a similar intercalibration with west coast laboratories using Juan de Fuca Strait and Lake Washington waters. The results illustrated the superiority of a combination of isotope dilution and clean-room techniques over the more conventional techniques of flameless atomic absorption and anodic stripping voltammetry. The lead level in sea water, when free from analytical contaminants from dust and aerosols, and recovery problems, appeared to be at an order of magnitude lower than that given by so-called 'current' techniques.

Similarly, mercury levels in sea water were found to be much lower when a cold-vapor u.v. method was used, compared to results obtained by previous workers. Investigations in station P waters, the southern Beaufort Sea, the eastern Pacific and Western Atlantic Oceans indicated the total inorganic mercury level to be between 5-15 ng/l in surface ocean waters.

The capability of the Division to perform high accuracy trace metal analysis was enhanced greatly with the installation of a Nuclide 12-90-SU mass spectrometer in September, 1975. This powerful instrument, plus contaminant-free sample handling techniques, makes it possible to establish trace metal levels with confidence and to provide absolute calibration to much faster but less accurate techniques of flameless atomic absorption and anodic stripping.



A Nuclide-90-SU mass spectrometer performs accurate measurements of trace metal levels in the marine environment

Under the Ocean Dumping Program, trace metal studies on lead, cadmium, zinc, copper, mercury and chromium were formulated to find out (1) the background levels and variability of these trace metals at a major dumpsite near Vancouver. (2) the increase in contaminant levels in sea water immediately after dumping; (3) the historical records of heavy metal contamination in undisturbed sediment cores and (4) the rate of adsorption or desorption of trace metals into sea water by dumped materials or surface sediment. These studies should show whether dumping of dredge spoils and other wastes will lead to significant increases in heavy metal contamination, and what would constitute safe dumping practice and safe dumping grounds.

Marine Carbon Budget Section

A. B. Cornford - Head (to March 1)
C. S. Wong - Head (from March 1)

*A. B. Cornford - radiocarbon, ^{13}C isotopic studies
C. S. Wong - Inorganic carbon system, air-sea CO_2 exchange
R. D. Bellegay
P. Munro
F. McLaughlin

*left in 1975

Burning of fossil fuels could alter the earth's climate. The heat budget of the atmosphere will be affected by the interference of increasing amounts of CO_2 content in the atmosphere due to burning of gas, oil and coal for home-heating and industrial activities. Between 50 to 75 per cent of CO_2 appears to remain in the atmosphere while the rest is absorbed by the ocean or the biosphere. Thus, to understand the global CO_2 problem, the three reservoirs, i.e. the atmosphere, the ocean and the biosphere, have to be studied simultaneously and their interactions have to be quantified for the construction of a predictive model.

The Section's research effort has been concentrated on the marine aspect of the global carbon dioxide cycle: (1) the marine air CO_2 increase; (2) the role of the ocean in absorbing CO_2 and (3) the effect of the marine biosphere.

Marine air CO_2 increase has been watched closely at ocean weather station P (50°N, 145°W). This time series from the only marine CO_2 station in the world is now in its seventh year. Weekly air samples were collected on the weatherships and analyzed in our infrared CO_2 laboratory, which also performed air CO_2 analysis and reference gas calibrations for other Canadian CO_2 stations, at Sable Island and Alert Bay, manned by the Air Quality Monitoring and Surveys Division of the Atmospheric Environment Service.

The role of the ocean in absorbing CO_2 is being studied in two ways: (1) the air-sea CO_2 exchange by continuous air CO_2 and pCO_2 sea-water measurements and radiocarbon studies at ocean weather station P, and (2) the carbonate chemistry of the surface sea water at station P and in the Pacific Ocean. Carbonate chemistry samples from ships of opportunity in the Pacific Ocean were also processed by the Sillen-Dyrssen technique to yield carbonate chemistry parameters of pH, alkalinity, total CO_2 and pCO_2.

The effect of the marine biosphere on the CO_2 cycle is being studied using a CEPEX enclosure of sea water. In the carbon budget, the magnitude of biological uptake has not been successfully quantified due to a large number of factors in the natural environment. These include temperature of the sea, diffusion, variation in water properties and, more crucially, our inability to assess the dimensions of the biological factors, eg. respiration, phytoplankton photosynthesis and organic carbon fluxes. The CEPEX approach, described in a later section, offers an optimum scale in strategy. It is intermediate between the large-scale natural open-ocean work, which is difficult for data gathering, and the laboratory-experimental scale, which is too simple and unrealistic for the highly complex natural system. A one-month preliminary experiment was performed in September, 1975, by adjusting the pH of a CEPEX enclosure to pH 7.6. Details are given in the Chemical Transfer Section.

Chemical Oceanography Section

R. W. Macdonald - Head

R. W. Macdonald - Coastal chemical oceanography, Arctic chemistry
C. S. Wong - Marine Pollution
R. D. Bellegay
C. M. Jackson
P. Munro
F. McLaughlin

Chemical Monitoring Program at Station P

Long-term trends of chemical parameters at ocean weather station P (50°N, 145°W) were monitored as a continuing effort of the Division.

Neuston-net tows were made between Victoria and station P to collect tar balls and other surface pollutants. Samples of total dissolved aromatic hydrocarbons in surface waters were also collected. Weekly samples of atmospheric CO_2, surface alkalinity, total CO_2 and surface radiocarbon were taken. Continuous shipboard infrared measurements of marine air CO_2 and pCO_2 were made on a quarter-yearly basis. Samples of nutrients were taken at station P to provide information about long-term fluctuations in relation to circulation and the marine food chain. The weathership program also included collection of tritium samples and measurements of mercury and dissolved aromatic hydrocarbons in sea water. (Bellegay, Jackson)

Beaufort Sea Baseline Studies

Project C-1: Distribution of tar and other particulate pollutants along the Beaufort Sea coast

This project hopes to establish the baseline distribution of particulate pollutants, especially tar and plastics, and hydrocarbon characteristics of the coastal sediments in the present day Beaufort Sea coasts. A coastal survey was conducted by Thalassic Data to cover some of the areas studied in the 1974 summer and new areas on the Tuktoyaktuk Peninsula. The major areas investigated included: (1) The Yukon coast from Shingle Point Spit to Herschel Island; (2) the front of the Mackenzie River Delta, including Garry, Pelly, Hooper and Kendall Islands, and (3) Tuktoyaktuk Peninsula, from Kittigazuit to Drift Point. As in the 1974 survey, no visual tar pollution or natural seepage was found, except for a piece of grease picked up at Drift Point. However, plastic wastes, in particular those related to marine seismic activities, were prevalent in coastal areas, even on stretches of beaches cleaned of such wastes in the 1974 beach walk. Beach and nearshore sediments, marine organisms and fish were collected and laboratory analysis made to establish their hydrocarbon characteristics. (Wong, Cretney)

Work-up of sea water samples for hydrocarbon studies in Beaufort Sea cruise, inside a portable clean laboratory on board MV Pandora II

Project C-3: Baseline information on chemical oceanography and Petroleum-based hydrocarbons in the southern Beaufort Sea

Objectives of this project are (1) to provide a comprehensive understanding of the chemical oceanography of the area and (2) to establish the baseline levels of petroleum-based hydrocarbons in the southern Beaufort Sea drilling area, by measuring classes of hydrocarbons and identifying some specific hydrocarbons in sea water, marine sediments, marine organisms, marine mammals and fish.

A cruise on the MV Pandora II was manned by Ocean Chemistry Division in August, 1975. No tar or plastic wastes were found in the Neuston-net tows. The levels of dissolved hydrocarbons in sea water were similar to those found in uncontaminated open ocean waters in the north east Pacific Ocean. The levels of dissolved gaseous hydrocarbons, including methane, ethane and olefins, were low in general. Mercury levels were among the lowest found in ocean waters. Using horizontal Miller net tows, rich pastures of phytoplankton and layers of zooplankton were found in deeper waters off the ice edge. The waters were so rich in copepods that in some cases almost 1 cc of natural oil could be collected from the net. An uncharted subsea 'pingo,' only 15 m from the sea surface, was discovered. Forty-eight stations and one 24-hour time series were occupied and the results are to be published as a Beaufort Sea final report. (Wong, Cretney)

North Atlantic-Pacific 75 Cruise

To utilize the ship time from Halifax to Victoria for the return trip of the MV Pandora II from the Arctic, a chemical oceanographic cruise was organized to collect sea water samples for T, S, O, nutrients, CO_2,, trace metals, particulates, hydrocarbons, mercury and surface tar so that properties between the Atlantic and Pacific oceans can be compared. A total of 17 oceanographic stations to a depth of about 4,000 metres were occupied during the 6,662 nautical miles track from Halifax to Victoria via the Panama Canal. Preliminary results indicate that a marked difference in hydrocarbon pollution existed between the two oceans. The Atlantic waters, in particular within the Gulf Stream, were polluted heavily by viscous fresh tar, while the Pacific waters at about 200 miles off the North American coast showed little or no tar pollution. Mercury was found to be low in general, between 5-15 ng/l, using a cold vapor atomic absorption technique on board. (Wong, Bellegay)Ocean. The

Chemical Transfer Studies in CEPEX

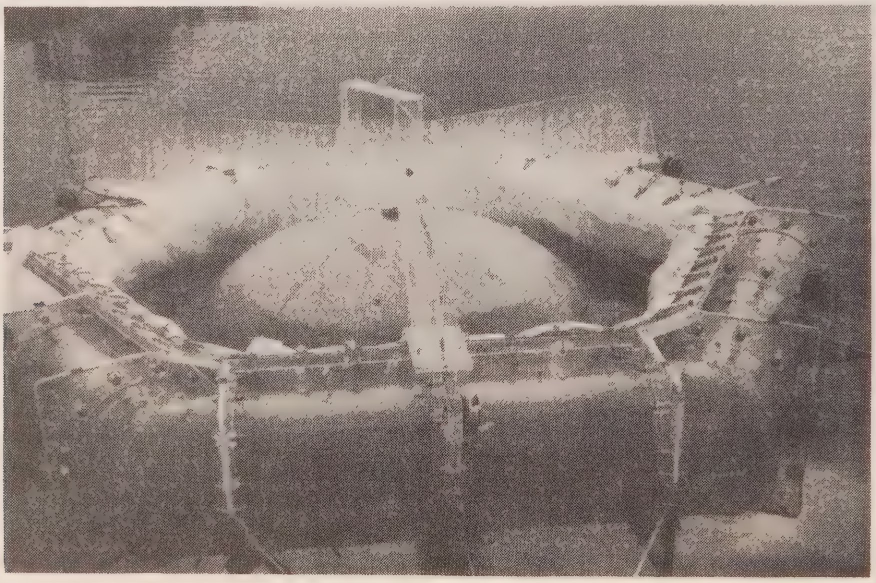
The Controlled Ecosystem Pollution Experiment (CEPEX) is an international cooperative program involving Canadian, American, British, Japanese and West German scientists to study the effects of pollutants on mixed trophic levels of pelagic marine organisms, using large enclosures of natural sea water in Saanich Inlet. Ocean Chemistry participation is in its second year and three experiments have been performed on carbon dioxide, cadmium and lead. Samples from a hydrocarbon experiment were also analyzed in Ocean Chemistry.

In the year 2070, CO_2 released by fossil fuel burning is expected to reach its maximum concentration in the atmosphere. Its chemical and biological effects on the ocean have not been investigated on a scale of the natural environment of the CEPEX dimensions. The Division's CO_2 experiment was conducted using a specially designed air-sea system with a 2 m diameter plastic dome enclosing an atmospheric reservoir over a ¼-scale CEE (Controlled Ecosystem Enclosure) with about 60,000 liters of sea water. The pH of the enclosed sea water was acidified to about 7.6 to

simulate a CO_2 condition possibly occurring in the year 2070. Carbonate chemistry parameters, C-14 uptake rate, phytoplankton biomass and major species identification, and nutrients, etc., were regularly sampled during the production and decay cycles, both for the acidified system and a control under undisturbed conditions. Preliminary results indicated that both the photosynthetic rate and biomass of planktons were unaffected by a shift of pH from about 8.1 to 7.6.

The cadmium experiment was carried out under the direction of Dr. K. Kremling who was with Ocean Chemistry under a one-year Canada-West Germany scientific exchange program. A control ¼CEE and another ¼CEE spiked with higher levels of cadmium were used and the cadmium contents in sea water and particulates were analyzed in the Division's clean laboratory. Preliminary results indicated large variations of cadmium: a rapid drop of the metal concentration in the upper 5 m with increasing production rate, and then an increase of the cadmium values to about the original value after the death of the phytoplankton.

A preliminary lead experiment was also carried out using three ¼CEEs, one as a control, one spiked with isotopic pb^{206} as inorganic lead and one with toxic tetraethyl lead. The purpose of this experiment was to have a general idea of the logistic and analytical problems associated with isotopic and organic lead spiking technique. Mass spectrometric analysis in progress indicates the applicability of the technique. In the summer of 1976 a full experiment of about one month's duration will be conducted. (Wong, Munro)



Ocean Chemistry Division used a plastic dome over a large enclosure of sea water at pH 7.6 to study the possible biological effects of CO_2 conditions simulated to concentrations possible by the year 2070, as part of the Controlled Ecosystem Pollution Experiment (CEPEX) in Saanich Inlet.

OCEAN PHYSICS DIVISION

P. W. Nasmyth - Chief of Division

Coastal Zone Oceanography Section

D. M. Farmer - Head

W. H. Bell
R. H. Bigham
L. F. Giovando
G. Kamitakahara
*L. P. Landry
A. Lee
J. H. Meikle
D. G. Sieberg
L. A. Spearing
J. A. Stickland
D. J. Stucchi

*Left in 1975

This year Coastal Zone Oceanography acquired a launch-based conductivity-temperature-depth profiler and data acquisition system. The first field trials of this equipment took place in August and the resulting data formed an essential part of our study of exchange through Quatsino Narrows. Despite a number of early technical problems, our CTD is now working well and we appear to be close to our goal of being able to take salinity and temperature profiles from a launch with an accuracy comparable to that of standard bottle and thermometer measurements.

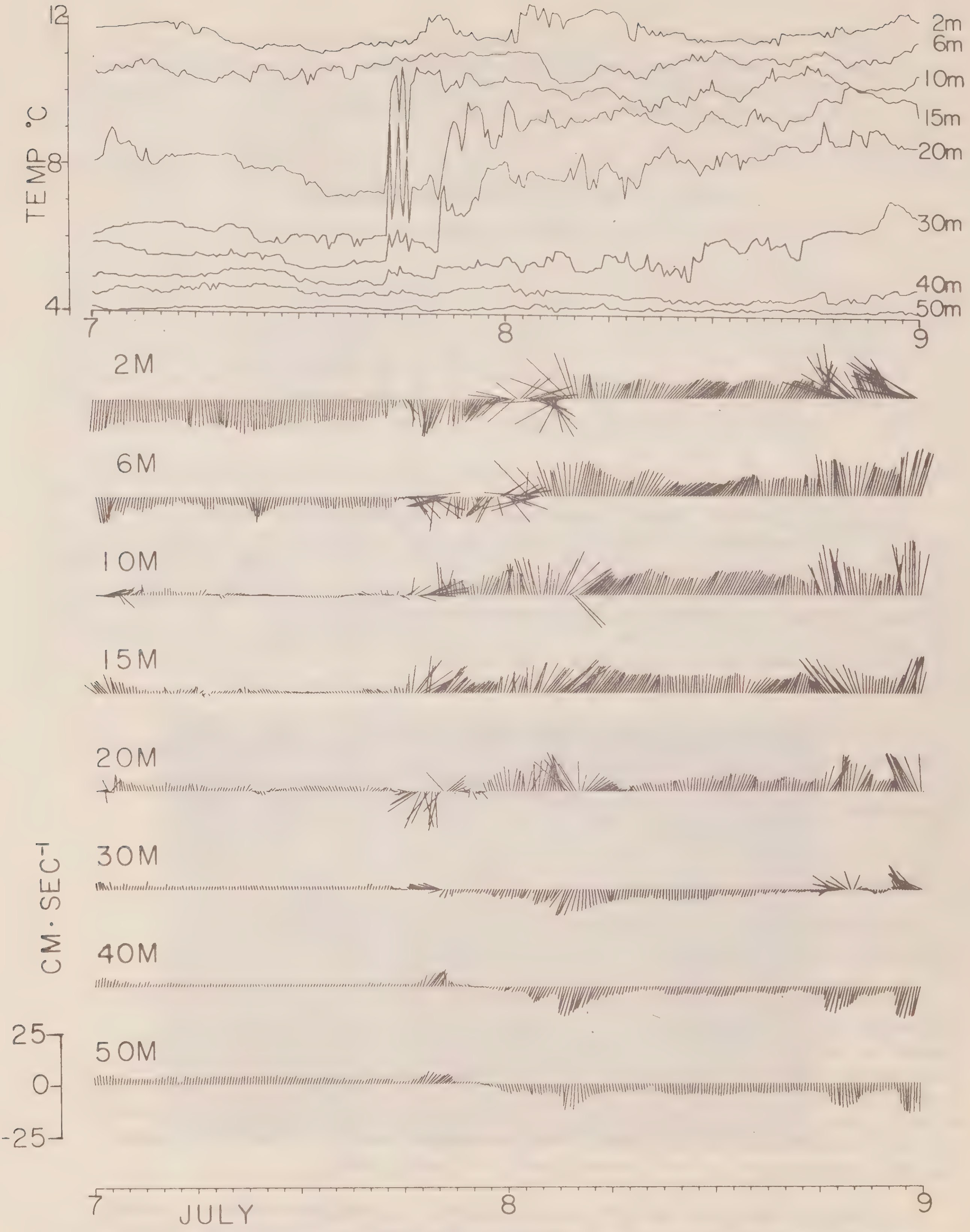
The field data processing capability developed for analysing recording current-meter tapes proved invaluable during our field operations. This year we spent considerable effort developing a similar capability for processing CTD tapes.

Fiord Studies

The large set of current-meter data collected in Howe Sound in 1972/73 has now been summarised and published.

Saanich Inlet, lying on the doorstep of the new Institute of Ocean Sciences, is ideally placed for studying certain exchange processes common to many B.C. fiords. This year we began a program of recording instrument moorings, set to sample at a low frequency, to measure small fluctuations in temperature and salinity at depth. These will be backed up with a series of temperature/salinity profiles and oxygen measurements in an effort to learn more about the exchange through Satellite Channel and its dependence on the oceanography of Haro Strait.

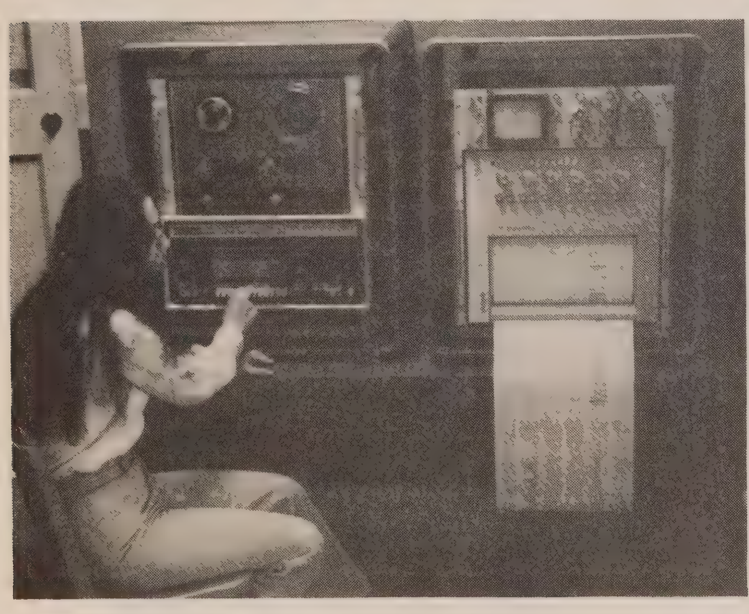
Our major program in 1975 was a study of the Rupert-Holberg system, together with the oceanography of Quatsino Narrows and Quatsino Sound. Following last year's preliminary current measurements in the Rupert-Holberg basin, we carried out a more detailed survey, backed up by a



Unique current measurements of an internal surge in Babine Lake. The sudden temperature fluctuations (top) indicate arrival of the surge. The 'stick diagram' below represents successive currents at different depths and clearly shows the rapid direction change associated with the surge.

series of CTD profiles, in August and September. The timing was fortuitous. In April, 1974, our observations had shown the presence of a tidally induced density current that plunged over the Quatsino Narrows sill and ran along the bottom of the basin. This year our measurement period (August-September) seems to have coincided with the transition from a near surface exchange with negligible current at depth, to a deep water exchange in which the flood tide spread throughout the water column. We also took a number of salinity/temperature profiles in the area. Although these are still in an early stage of analysis, it is already apparent from time series taken within the Narrows that the flood waters possess appreciable density structure despite the strong tidally generated mixing.

In order to obtain a longer term description of the exchange processes occurring between Quatsino Sound and the Rupert-Holberg system, recording instruments set to measure small fluctuations in temperature and salinity have been moored both inside and outside of the narrows. By carefully relating salinity and temperature changes between different instruments, we have been able to track changes in the exchange mechanism as it switches from deep to surface exchange and back again.



Portable data translation system, designed for installation in small oceanographic launch, allows for immediate replay of instrument data tapes in the field. Entire system travels in two shock-mounted waterproof field cases.

Task Forces, a Buoy Model and Other Coastal Studies

Contributions have been made to a number of environmental impact assessment programs. These have included studies concerned with the proposed expansion of Vancouver International Airport, suggested sites for a proposed steel mill, and also for new and enlarged ferry terminals. An oil-spill scenario was developed for use in Canada-U.S. discussions on environmental aspects of a tanker terminal in the State of Washington.

A numerical model has been developed to simulate the static deformation of an oceanographic mooring by currents. This model brings together a number of relevant aspects that have been treated separately elsewhere and it will serve as a useful tool in designing future mooring operations, especially in swiftly flowing waters.

In conjunction with the Institute of Oceanography at the University of British Columbia, two computer simulated movies have been made showing the movements of drift drogues in studies of Pendrell Sound and Port Mellon. The Pendrell Sound study is in support of Fisheries Research Board investigations of oyster spat operations; detailed heat budget of the sound is now being carried out with IOUBC.

We have begun a new program, to be conducted largely under contract, to take a closer look at the substantial set of data in the form of daily salinity and temperature measurements collected at lighthouse stations along the B.C. coast. The first phase of this project, which comprises the development of appropriate analysis techniques and their application to three lighthouse series, is now complete. Future work will cover remaining stations and a look at ways of placing the sampling program on a more rational footing.

Although the field operations in Babine Lake are concluded, we are continuing analysis of the large data set accumulated in 1972-73. This year we continued our study of internal surges and related the observations to existing non-linear wave theory.

Numerical Modelling Section

R. W. Stewart - Head

P. B. Crean	R. F. Henry
M. Foreman	P. J. Richards (Computing Services)

Georgia Strait Model

The results obtained from a vertically integrated numerical model simulating the propagation of mixed tides in the waters between Vancouver Island and the mainland suggest the existence of large residual currents in regions characterized by complex topography and strong tidal streams. To further investigate these residual currents, and also to provide more detailed resolution of the velocity fields in certain important areas, a model employing a mesh size one half that used in the previous work has been developed and is undergoing trials.

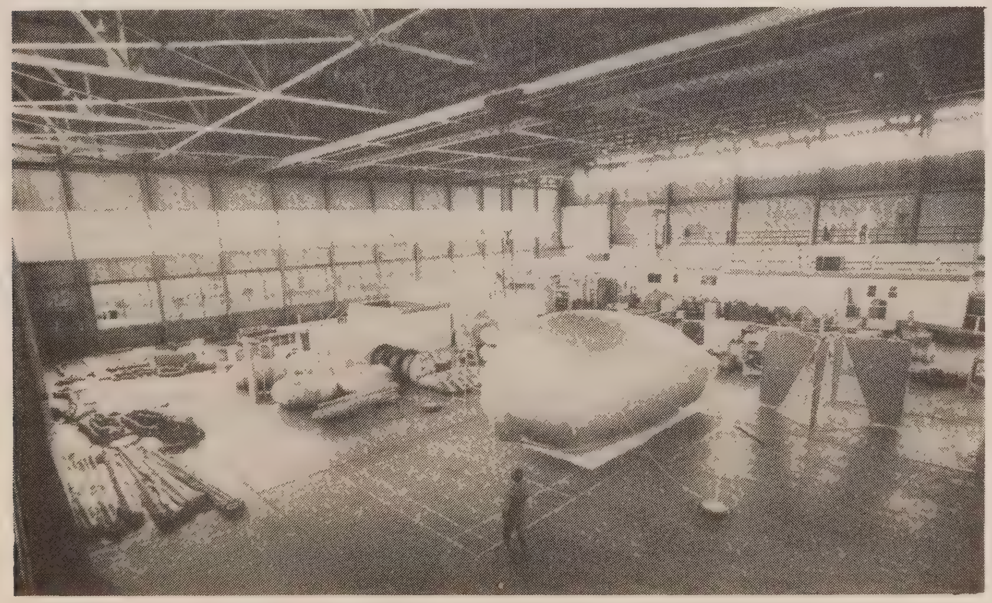
In collaboration with the Institute of Oceanography, University of British Columbia, field studies are being undertaken to determine the factors governing the movement of the Fraser River discharge away from the river mouth and in particular to examine the formation of small scale fronts between the river water and the sea water in the Strait of Georgia.

The observations are being made from a shallow draft launch and include drogue tracking, and CSTD, dye and velocity profiles. It is proposed that the results of this study will eventually be incorporated in a numerical simulation of estuarine processes in the Strait of Georgia. (Crean)

Storm Surges

Two storm-surge models of the southern Beaufort Sea were completed, one a large-area model designed for detailed retrospective studies, the other an economical small-area model designed for inclusion in the environmental prediction system at Arctic Weather Central, Edmonton.

Trial runs conducted and compared with historic surge records indicate that the major features of the surges are correctly simulated. Development work will continue as more surge records are acquired. (Henry)



Helium-filled balloon, used for special photography by Remote Sensing Section, is tested for leakage in the hangar

Offshore Oceanography Section

J. F. Garrett - Head

C. De Jong
*A. Hartley
P. Kimber
L. S. Kuwahara
*E. W. Marles
B. G. Minkley
S. Tabata
R. E. Thomson

*Left in 1975

Weathership Oceanography

This was the 19th year for the oceanographic time series at ocean weather station P (50°N, 145°W). Of the seven patrols manned by oceanographers this year, the manning of five was contracted to Chemex Laboratories of North Vancouver, under contract to Offshore Oceanography, and of one to Seakem of Victoria, under contract to Ocean Chemistry. Six data reports were produced bringing the series up to volume number 66. (Garrett)

Oceanography of the Offshore Region of British Columbia

The quality of surface salinity and temperature observations along Line P over the past few years permits resolution of fine surface features. The persistence in time and location of some of these features, such as the relative minima and maxima of salinity and temperature, suggests the occurence of mini-oceanographic boundaries or fronts along the Line, possibly caused by a unique circulation system in the region.

A cruise carried out aboard CNAV Endeavour from August 18 to September 10 off the B.C. coast had as one of its objectives the observation of surface salinity and temperature continuously along the cruise track, in a program similar to those carried out from the two weatherships, to permit the delineation of at least some of these boundaries. Information acquired should help establish how such boundaries come about.

Data obtained along the seven tracks parallel to Line P and the two tracks perpendicular to them exhibit as much variability as has been observed along Line P. In some cases minima and maxima along the track appear to extend meridionally for over 400 km. Comparison of the contours drawn from continuous data and discrete station data show that the former yield, as expected, considerably more detailed and complicated surface patterns, although the gross features of salinity and temperature of both sets are similar.

Five relative salinity minima represented along Line P to the east of longitude 136°W can be attributed to the advection of low-salinity water from a number of coastal areas. The salinity minimum closest to the coast appears to have its origin off Tofino, and is believed to be a

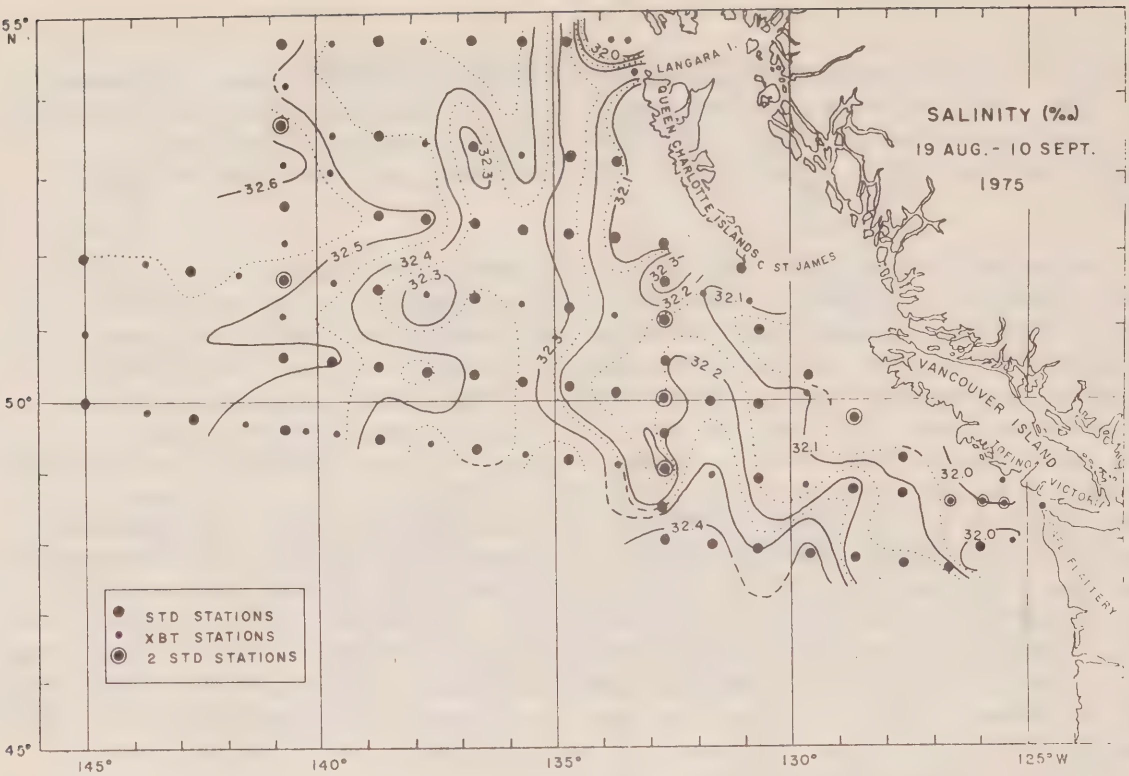
combination of the water from Juan de Fuca Strait and drainage-influenced water from the west coast of Vancouver Island. Inshore from this location is an area where the salinity is relatively high and the water cold, probably due to either upwelling or tidal mixing over the shallow banks nearby.

The second minimum of salinity is located approximately 200 km west of the first. It appears to have its origin along the west coast of northern Vancouver Island and probably is a mixture of the local west coast water and that from southern Queen Charlotte Sound. The third minimum, lying approximately 100 km west of the second, almost certainly originates in Queen Charlotte Sound. It appears possible that the second and third minima have a common source, as they appear to be separated only by a narrow ribbon of high salinity water. The fourth minimum appears to be associated with the low salinity water of northern Queen Charlotte Sound, and also with the water lying west of the southern Queen Charlotte Islands. It is not clear whether or not the low-salinity water found in the latter location initially originated in the Sound. The fifth minimum located at approximately 136°W longitude is of particular interest as it appears to have ocurred during 1973, 1974 and 1975 at about the same location. From the data available it is difficult to trace the origin of this minimum. It may originate even farther north than the Queen Charlotte Islands.

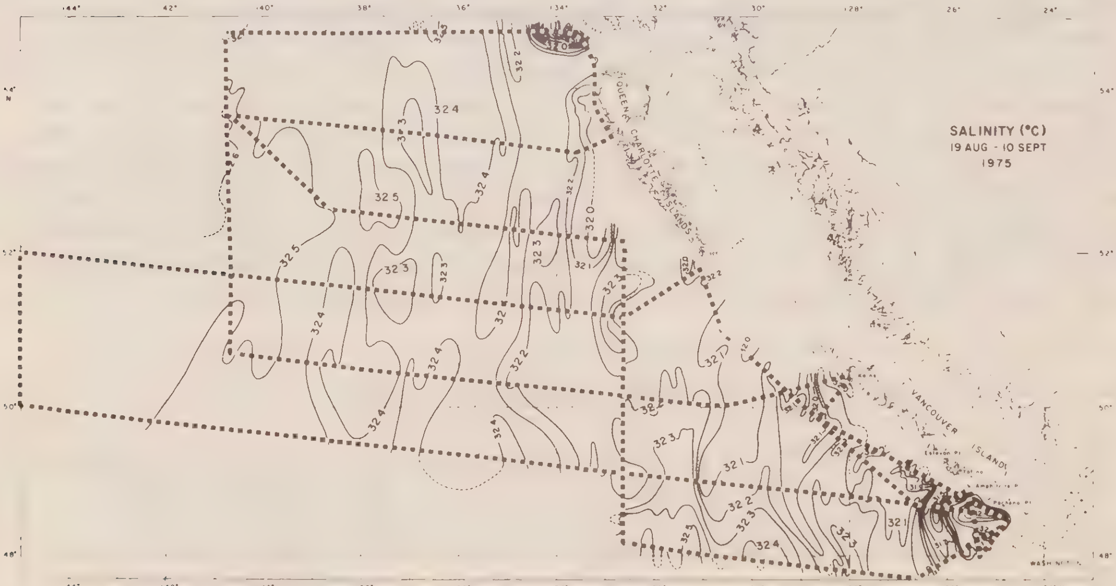
Near surface temperature distribution, based on the continuous data, is more complicated than salinity and more difficult to interpret, although some features such as tongues of cold or warm water, can be interpreted in terms of advection. For example, the cold water lying northeast of station P can be considered as the inflow from the centre of the Alaska Gyre and the warm water that intercepts Line P can be considered as the advection of warm water from the south. Also, some of the minimum temperatures observed along the line east of longitude 136°W appear to be due to the advection of cold coastal waters. One difficulty in the interpretation of temperature distribution of the surface layers of the ocean is the greater sensitivity to summer heating than to surface dilution. Thus, during an interval of three weeks (the duration of the cruise) significant changes in temperature can occur. (Tabata)

Sea Surface Temperature and Infrared Satellite Imagery

The main obstacle to the successful application of satellite sensing to oceanography of the offshore region of B.C. is that a relatively large area off the coast is seldom cloud-free. However, NOAA VHRR imagery for September 11, 1975, showed a clear area extending south from the west coast of the Queen Charlotte Islands to the latitude of the Columbia River. The infrared imagery depicted the coldest waters off the mouth of Juan de Fuca Strait, agreeing with temperature observations made during the August-September cruise. It also showed patches, or fingers, of cold water occurring at about four locations from mid-Vancouver Island to the area of Cape St. James. These patches extend



Distribution of surface salinity (°/₀₀) from two sets of data obtained from CNAV Endeavour during a three-week summer cruise. Distribution was determined from discrete sampling, represented by dots. The second set of data, indicated by ⊛, did not materially affect the salinity contours except at the entrance to Juan de Fuca Strait.



Distribution of surface salinity (°/₀₀) as determined from continuous sampling along the cruise track, represented by dashed lines, shows the fine detail obtained when continuous data were used. Parallel orientation of contours to the meridians is influenced by the fact that sampling was carried out on seven lines parallel to Line P (including Line P itself) and only two lines perpendicular to them. This gave more than three times as much continuous data along the latitudes than along the meridians.

seaward from the coastal areas, and some at least appear to extend toward Line P. Such interpretation is in accord with that deduced from the examination of salinity and temperature data collected during the August-September cruise.

Oceanographic Data Quality

The cruise also provided an opportunity to examine the quality of 'surface' temperature and salinity data obtained by means of the salinograph-thermograph, which records the properties of sea water pumped through the sea water loop, by comparison with the laboratory determination of salinity of water collected by the sea water loop and in bucket samples, and by the Guildline CTD. Only the salinity data collected by the different methods were examined, as the temperatures obtained by the sea water loop were apparently influenced by the ambient temperatures of the ship, and were not considered sufficiently accurate to warrant detailed comparison with those obtained by other means.

The salinities determined by the salinograph-thermograph were 0.11°/₀₀ higher than those measured by a laboratory salinometer which was routinely calibrated with Copenhagen water. When this figure was applied as a correction to the salinograph-thermograph values the resulting salinities were within 0.01°/₀₀ of the laboratory salinometer values in more than 75 per cent of the cases. Thus, when the salinograph-thermograph is properly calibrated it is capable of yielding salinity values that are within 0.01°/₀₀ of the actual values. Salinities obtained by the Guildline CTD were 0.04°/₀₀ too high. There was no significant difference between salinities determined from bucket samples and those from the sea water loop (at 3 m depth). A conclusion can be drawn that the surface bucket salinities and the 3 m loop salinities are the same in open waters off the coast. According to data obtained from CTD casts the 3 m and 10 m salinities are, in most cases, the same. The implication is that the higher salinities of surface samples as compared to 10 m values in some earlier data from the North Pacific are probably erroneous in most cases. For detailed distribution of surface salinity these values should be used with caution, unless the accuracy sought is less than 0.01°/₀₀.

Internal Gravity Waves

Internal gravity waves which are propagating vertically through a randomly varying horizontal wind (or current) shear are shown to lose energy through scattering. As a consequence the usual growth in amplitude of these waves as they propagate into regions of decreasing fluid density is somewhat curtailed while the decrease in amplitude with increasing density is enhanced. By treating the problem stochastically, the amount of dissipation is determined explicitly, without the need for artificial viscosities. (Thomson)

Longshore Currents in the Strait of Georgia

Between May and September, two moored current meter lines with surface floatation and two thermistor chains were deployed westward of the front of the Fraser River Delta. Their purpose was to determine the relation, if any, between onshore propagating internal waves and the persistent northward flow previously observed within two kilometres of the delta. One 15 m depth current meter was anchored about five kilometres offshore, outside the longshore regime; the other was anchored within the regime. Unfortunately, damage to instruments during mooring procedures, malfunctioning thermistor chains, and collisions with shipping greatly reduced the amount of usable data. Good data is presently being worked up. (Thomson)

Lead Patterns in Sea Ice

Satellite imagery of the ice-covered Canada Basin in the Arctic Ocean shows the presence of large-scale spatially rectilinear leads separated by distances of about 100 kilometres. An interpretation in terms of the reflection of planetary waves originating from the northern Basin, self consistently and in accord with other information, describes many of the observed features. An alternate explanation based on the structural dynamics of the ice in conjunction with the winds and currents is being investigated. (Thomson, with J. Marko)

Potential Vorticity Within the Ocean

The balance and redistribution of potential vorticity in a turbulent, inhomogeneous ocean has been examined analytically. A vorticity law describing the way vorticity is lost and gained in a closed ocean basin was developed. The theory of Welander (1973), concerning large scale circulations driven by turbulent mixing of potential vorticity, has been examined in detail. Our investigation reveals important flaws not only in Wellander's argument but also in the classical mixing-length theory of Prandtl (1925) and of Taylor (1915). (Thomson, with R. W. Stewart)

Pacific Yachting Series

Three detailed articles on what is known about the currents and waves in the Strait of Georgia appeared in Pacific Yachting, a magazine of about 20,000 subscribers published in Vancouver. In addition one article dealt with the characteristics of surface and internal gravity waves in general. Also appearing in 1975 were articles on currents in the Strait of Juan de Fuca, Upwelling, and Tidelines. (Thomson)

Beaufort Sea Near Surface Currents

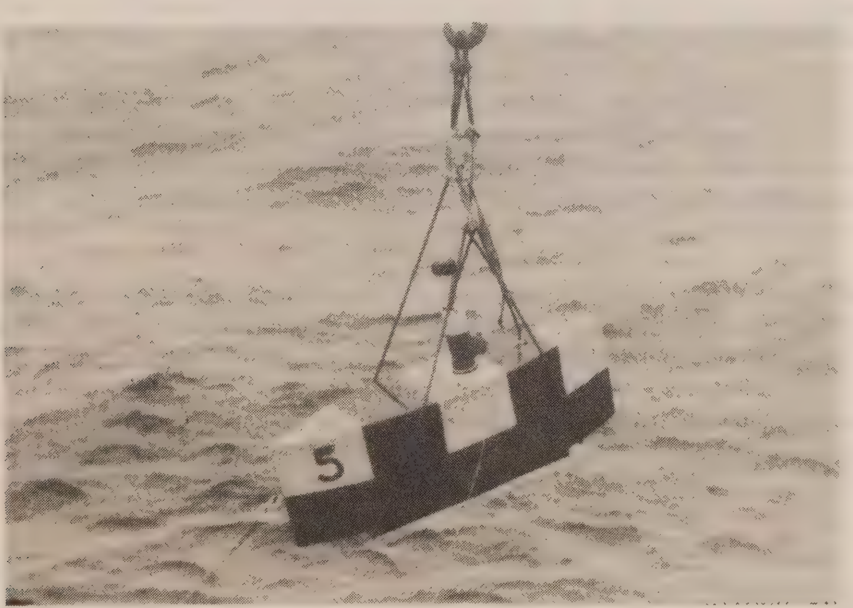
As part of the Beaufort Sea Project the open water surface currents and their relationship with the wind in the southern Beaufort Sea were observed for the second summer. The technique of deploying and tracking radio beacon equipped drogues using aircraft was somewhat improved this year, but the most important improvement was in the ice conditions which

permitted work up to 71°N. The wind is the major influence on the surface currents, particularly during strong winds, but there is also a significant component of the motion associated with the flow of the fresher Mackenzie River water over the underlying ocean water. This means that current predictions based on the wind alone can not be very reliable.

This study was carried out by Dobrocky Seatech of Victoria under contract. (Garrett)

Drift Buoy Development

The availability of the RAMS location and data collection system aboard the Nimbus 6 satellite launched in June encouraged a revival of our program for developing expendable satellite tracked drifting buoys for ocean current measurements. A boat-shaped hull was designed and constructed of plywood for attachment to a string of floats supporting a 25 m or 50 m 'window blind' drogue. Eight buoys of this type were launched in mid-December, seven of them at 50°N, 135°W, and one at the dock at Patricia Bay. Two of the open ocean buoys failed while being transported to the launch site, but the five that were working when launched were still transmitting at year end, having drifted about 20 miles towards the south east. (Garrett)



Boat-shaped buoy, shown as it was launched from CSS Parizeau
in December, is one of five being tracked by
satellite for ocean current measurements

Frozen Sea Research Group

E. L. Lewis - Head

*J. D. Bradbury
J. W. Butcher (Computing Services)
R. A. Cooke (Survey Electronics)
A. W. Koppel
R. A. Lake
A. E. Moody
S. W. Moorhouse
P. E. Oswald
R. G. Perkin
D. L. Richards
R. B. Sudar
D. R. Topham
E. R. Walker
*P. Wadhams (Postdoctoral Fellow)

*Left in 1975

Two field trips to d'Iberville Fiord in northern Ellesmere Island were made during 1975. In April the lowest air temperature we have ever recorded, -49°C, was measured. During this trip water structure profiles were made along the fiord. Current measurements were made with the CMI (Christian Michelsen Institute, Norway) ultrasonic instrument and a prototype telemetering current meter system was tested. This system, with sensors affixed to the ice-bottom and on the sea bed, is for use in the 'Pipeline Project', in April, 1976, when 10 such systems will be deployed across one of the proposed inter-island gas pipeline crossings north of Parry Channel.

On the second trip, in June, the weather was much warmer than normal and river runoff began two weeks earlier than usual. Runoff measurements were made on rivers near our base. Water structure and current measurements were made in the fiord. The telemetering current meter system was further tested.

Professional staff have been heavily involved in task forces concerned with industrial developments in Arctic regions. These relate primarily to mine tailing disposal into the sea at various locations, and to offshore drilling for oil in the Beaufort Sea and Queen Elizabeth Islands. Arctic offshore industrial proposals are referred to Frozen Sea Research Group for comment on potential environmental consequences, and this aspect of our work now utilises more than half of the man-year allotment.

Major projects are listed below, including both in-house and contracted studies.

1. Water circulation associated with a blowout from the sea bed was simulated at full scale, using two large compressors at a site off Patricia Bay in Saanich Inlet. (Beaufort Sea Technical Report No. 33)

2. The statistics of the ice cover in the Beaufort Sea as derived from two years of laser profilometer data have been investigated and references made to its potential for oil containment in the event of a spill. (Beaufort Sea Technical Report No. 36)

3. Oil-air mixtures have been injected under pressure into a tank of sea water to investigate possible oil/water emulsion formation near the sea bed during the course of the blowout. (Beaufort Sea Technical Report No. 33.)

4. Extensive assistance was extended to NORCOR in connection with their contracted field studies involving oil spilled under growing sea ice at Cape Parry, N.W.T. (Beaufort Sea Technical Report No. 27)

5. A study of the possible climatic effects of any change in surface albedo of the sea ice due to oil contamination has been carried out. (Beaufort Sea Technical Report No. 35.)

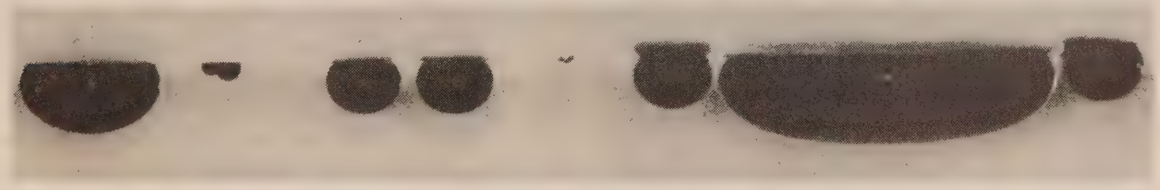
6. Laboratory studies of the behaviour of oil under ice and minimum thickness of oil in leads have been undertaken by the Imperial Oil Company, Calgary, under contract and a report is to hand.

7. Assessments of the environmental effects of mine tailings disposal into Arctic fiords has been attempted. Mining sites on Little Cornwallis Island and on the shores of Strathcona Sound have had the greatest prominence.

During the past eight months equipment has been purchased, modified and built to undertake the measurement of currents at probable Arctic gas pipeline crossings. Detailed tests of a CMI ultrasonic current meter that has the capability of detecting currents in the range of 1 mm/sec. have been made in the laboratory and in the field. Although further work is required, the instrument has produced useful results and in the future is likely to produce major changes in our understanding of water movement.

Further development of the circulator which allows calibration of an in situ CTD instrument using its own conductivity cell, has brought the device to the stage where it will be commercially produced in 1976.

In association with Coastal Zone Oceanography an international cooperative project of fiord research has been set up under the umbrella of IDOE. Some exchange of personnel with Norway has been arranged and Chile, Denmark, Iceland and the U.S. have indicated interest in participating.



Sessile oil drops photographed under sea ice have the minimum thickness of oil possible at the ice/water interface (approx.8mm). Thickness is controlled by a balance between gravitational forces and forces due to surface tension.

Remote Sensing Section

J. F. R. Gower - Head

J. S. Wallace

R. L. Grasty - on secondment from Geological Survey of Canada, Ottawa

R. A. Neville - NRC Postdoctoral Fellow

B. Oliver - NRC Postdoctoral Fellow

During 1975 the Remote Sensing Section was occupied with spectroscopic measurements of water colour using the 256 channel silicon diode spectrometer, with tests and target position measurements using the MIDAS Marine Inertial Data Acquisition System, and with photography in support of other programs at the Institute of Ocean Sciences. Analysis of image data from NOAA's VHRR radiometer continued for sea surface temperature measurements with S. Tabata (Offshore Oceanography Section), and altimeter data has been received from GEOS-3 satellite for wave height analyses.

Aerial Spectroscopy Using the 256 Channel Silicon Diode Spectrometer

The instrument was installed in a Beaver float plane and used on a number of trial flights during the spring of 1975. Spectra were collected viewing the water at the Brewster angle through a polarizing filter and were compared with chlorophyll concentrations in the water measured by the University of Victoria. These showed the expected changes in blue/green ratio with chlorophyll content and also demonstrated that the chlorophyll fluorescence line near 680 nm could be used as a chlorophyll indicator for low level flights even under cloudy conditions. Further investigations of this fluorescence line are being made using spectra from a research ship, a dock and over a CEPEX enclosed environment bag. Laser-induced fluorescence lines were also measured in the laboratory.

The spectrometer was flown on a CCRS DC3 during the joint chlorophyll sensing experiment off Yarmouth, N.S., in August. Soil spectra were collected in the lower Fraser Valley in support of research at UBC.

The spectrometer has been a useful source of high quality fast scanned digital spectra covering 380 to 1065 nm with a resolution of about 10 nm, and should prove useful in an even wider range of research projects. The airborne installation allows for removal of dark currents, collection of sky spectra and monitoring of the resulting spectral ratios. (Neville)

MIDAS -- Marine Inertial Data Acquisition System

The system has an LTN-51 inertial navigation unit interfaced to a mini-computer. Navigation and altitude data and data from sensors and other instruments are collected by the mini-computer and stored on digital videotape. Bench and truck trials showed that the system can form the basis of an extremely precise track recovery system. Removal of the measured INS velocity drift in ground tests gave positions accurate to about 20 feet over a half hour run in a truck.

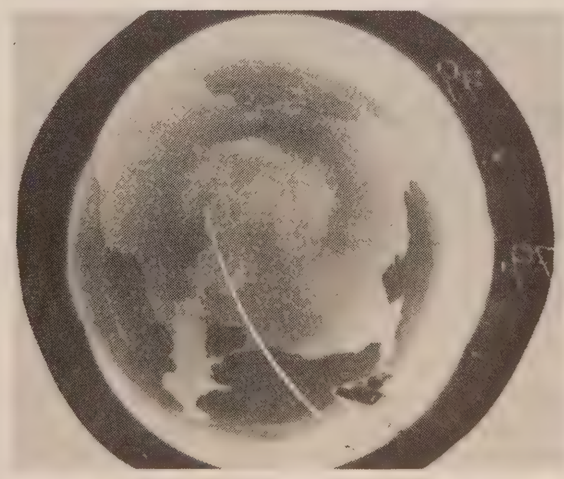
The system is now being flown in a Beech 18 aircraft belonging to the B.C. provincial government. An electronically read gun sight system mounted in the nose is used to determine the directions of reference positions at sea level as the aircraft passes approximately overhead. The sight allows the aircraft's position to be defined to about ±30 feet, and sightings at 10-minute intervals are sufficient to define the INS drift errors to this same accuracy. The position of any intermediate target can be determined to a similar accuracy. Tests with the system have so far included position measurements of coastal navigation markers and of freely drifting drogues.

The MIDAS system has also been used to form thermal images from the output of a PRT-5 infrared scanner giving 400 foot resolution over a swath width of five miles. Soil spectra gathered in the lower Fraser Valley were also collected using MIDAS in the Beech 18, with the spectrometer data being recorded along with track and time information. Further track recovery and mapping software are now being written and other uses explored.

Photography In Support of Other Programs

A variety of photography was carried out over the year to develop and demonstrate techniques and to support other programs.

1. Balloon Photography: A series of 35 mm photographs was taken from a balloon over Rupert Inlet on Vancouver Island, B.C., to map the upwelling of mine tailings at different states of the tide. The balloon had a volume of 1600 cubic feet and, filled with helium, provided a net lift of about 60 pounds. This was used to carry a motor-driven Nikon camera equipped with a fisheye lens and triggered at 10-minute intervals by a self-contained intervallometer. The streamlined shape of the balloon allowed it to remain near the zenith in most wind conditions and it could be conveniently handled and flown from a small launch by a crew of two. Several useful series of pictures were obtained for cost and effort that compared very favorably with other means of photography. The balloon was flown by Dr. M. Miyake's group at UBC under contract.



Fish-eye photograph of turbidity near Quatsino Narrows is one of a series taken from a balloon by Remote Sensing Section. Detailed current meter observations made by Coastal Zone Section were directed at understanding the mechanism that brings mine tailings from the deep water of Rupert Inlet to the surface.

2. CCRS Falcon Flight over Vancouver: At our request the Falcon aircraft belonging to the Canada Centre for Remote Sensing flew high level visible and thermal imagery over Vancouver and the area of the Fraser River plume during both flooding and ebbing tides on June 11. Surface current data were collected at the same time in Burrard Inlet. Details of the flow shown by Fraser River silt in the photos and by thermal imagery could be compared with this data. Surface water temperatures were collected during the day by a number of different agencies to calibrate the thermal imagery, and a low level flight with a PRT-5 radiation thermometer was also used to check atmospheric attenuation in the infrared.

3. Ships in English Bay: In support of a surface current survey of Burrard Inlet a series of 8 mm time-lapse pictures was taken at 10-minute intervals from a mountain side to show the orientation of ships in English Bay. The fixed location of the camera made the film easy to analyse and even though the target scene was viewed at a glancing angle of less than 10° the ship orientations could be measured to ± 20° during daylight periods from June 1 to June 10.

Thermal Imagery Enhanced to Show Sea Surface Temperatures

Thermal VHRR imagery from NOAA satellites can be enhanced to show variations in sea surface temperature as small as 0.5°C. These images show the effects of coastal upwelling as well as other more transient temperature changes which may be associated with winds or fresh water runoff. Some enhanced images are available from NOAA but, to give good coverage of the area off the B.C. coast, taped data was ordered and software was developed to display the enhanced imagery. Comparisons with Station P and other ship data are still continuing.

Arctic Marine Science

A. R. Milne - Head

R. H. Herlinveaux
A. L. Watson - on contract
B. D. Smiley
D. Aanhout - on contract

The Beaufort Sea Project

The Beaufort Sea Project is an Arctic marine environmental assessment program financed by the Federal Government and 18 companies of the Arctic Petroleum Operators Association. Field studies ended in September and were followed by intensive data analysis and report compilation for 40 studies.

A preliminary assessment based on these studies describes the likely environmental impact of an underwater oil well blowout at sites proposed for exploratory drilling in the southern Beaufort Sea in 1976. Detailed technical reports and six general 'overview' reports of the studies will be available early in 1976.

Details of contributions made by Institute of Ocean Sciences personnel are reported by Chemistry, Physics and Ship Divisions and by the Tidal and Current Survey Section of the Hydrographic Division.

Ocean Mixing Section

P. W. Nasmyth - Head

A. E. Gargett
G. W. Chase
R. C. Teichrob

During 1975 an analysis system was developed for turbulent velocity data obtained during a field trip in early 1973, when tows of roughly 24-hour duration were carried out in a variety of areas in the eastern North Pacific. Two were in coastal boundary regions off Vancouver Island, one in sub-arctic waters near ocean weather station P, one in the eastern North Pacific water mass, and one in a subtropical region east of the Hawaiian Islands.

Analysis of the vast quantitites of data involved has been a problem because of the equally vast amounts of computer time required, until recently, for spectral analysis. The system we have now developed uses a Fourier transform 'box' designed to operate as an integral part of a mini-computer system at speeds which are orders of magnitude faster than the FFT algorithm on large computer systems. Velocity data is read from multiplexed digital tape, pre-whitened by first-differencing, and corrected for noise generated by plankton particles contacting the velocity probe. The spectrum is then computed and corrected for the measured response function of the probe and for the effects of both analog and digital pre-whitening. Block-averaging of spectral estimates is carried out, and the average estimates and their variances are stored on magnetic tape, where they are available for further display processing. The same system, with relatively minor changes, can be used to analyse the high frequency temperature data obtained on the same cruise. The system should allow us to analyze all uncontaminated data, resulting in a large increase in the information available from direct measurement about turbulent mixing of momentum and heat in the North Pacific.

In association with Dr. T. Osborn of IOUBC, Dr. A. Gargett participated in a joint microstructure experiment organized by the Woods Hole Oceanographic Institution and carried out in the Atlantic during October and November.

The purposes of the experiment were (1) to allow intercomparison of various instruments which purportedly measure the same things; (2) to integrate the various scales of physical variables measured by different instruments and (3) to investigate a theoretical mechanism predicting different mixing effectiveness around islands (Bermuda).

The third aim may not be realized due to lack of a strongly directional flow onto the island at the time of the experiment. The other two aims

should be fully realized with the analysis of data from many simultaneous drops of six free-fall instruments at mid-ocean, near-island and Gulf Stream locations. Participants have agreed to have data from four stations processed by September, 1976, when the first attempt at intercomparison will be made. The IOUBC instrument was used in 31 drops, and measured two components of turbulent velocity shear, temperature and depth from the surface to maximum depths of around 800 m.

Work has continued on the new instrumentation and stabilizing system for the submersible Pisces IV. The stabilizing fins were delivered on Christmas Eve and at time of writing have been attached and have undergone preliminary trials with very promising results. Even at full throttle, piloting appears to have become a 'hands-off' operation with no detectable pitch or yaw. Further trials will be carried out with accelerometers mounted to measure and record submarine motion and vibrations quantitatively.

A first set of instruments to measure temperature, conductivity and velocity (in two dimensions) microstructure, as well as mean submarine motions, will be ready for test and de-bugging as soon as trials of the fins are completed.

The submersible Pisces IV suspended from A-frame on stern of Pandora II in preparation for launch. New stabilizing fins in retracted position during launching will be lowered slightly and angle of attach adjusted by hydraulic control after Pisces is in the water.

SHIP DIVISION

E. N. Geldart - Regional Marine Superintendent

F. S. Green - Assistant Marine Superintendent (deck)
D. Marr - Assistant Marine Superintendent (engineering)
G. R. Meek - Submersible Operations Manager

The Pacific Region Ship Division provided ship, submersible, launch and depot support for the 1975 hydrographic and scientic programs and for several federal departments and universities.

CSS PARIZEAU

Master - A. G. Chamberlain Chief Engineer - R. Parkinson

Following annual refit and drydocking at Yarrows Ltd., Victoria, B.C., CSS Parizeau was employed on biology, Simon Fraser University, IOUBC; ocean chemistry, OAS; current metering, OAS; and Towex, DND. The tanker route and resource survey along the west coast of Vancouver Island was the major project of the year.

CSS Wm. J. Stewart

Master - K. J. Sjoholm Chief Engineer - J. D. Henderson

CSS Wm. J. Stewart was drydocked and refitted at Yarrows Ltd., Victoria, B.C., and prepared for the annual hydrographic survey season which began April 21. The major project for the year was a survey of the proposed tanker route in the Strait of Juan de Fuca and off the west coast of Vancouver Island, including Barkley Sound. This work was finished September 20, approximately one month earlier than usual, and the ship was decommissioned.

CSS VECTOR

Master - J. C. Marston Chief Engineer - J. Peat

CSS Vector received her annual drydocking and refit in Yarrows Ltd., Victoria, B.C., and carried out the following programs: physics, IOUBC; chemistry, PEI, OAS; biology, IOUBC; geology and geophysics, EMR; chlorine tank search, OAS and MOT, and cold water survival, UVic.

CSS RICHARDSON

Master - M. G. Wheeler — Chief Engineer - I. N. Henderson

CSS Richardson was engaged in brisk activity during the first eight months of the year supporting the following programs: physics, OAS and IOUBC; tide and current studies, OAS; sewage disposal studies with Dobrocky Seatech; chlorine tank search, OAS and MOT; assistance to resource survey party. She was decommissioned early in September due to budgetary restraints.

CFAV LAYMORE

Master - M. J. Dyer — Chief Engineer - H. R. Doherty

CFAV Laymore was operated on a cost-sharing basis between DOE and DND during 1975. Activities included support for the following: Canadian Forces divers, DND; ecology, PEI; survival, UVic; biology, IOUBC and FRB; acoustics, DREP; geology, EMR; geophysics, IOUBC, and tide and current studies, OAS.

M. V. RADIUM EXPRESS

Master - J. P. O'Sullivan — Chief Engineer - Woodrow Butler

The hydrographers reported another successful summer survey season on this vessel which is engaged on a five-year charter for the annual hydrographic surveys of the Mackenzie River system between Hay River and the Mackenzie Delta.

MV PANDORA II

Master - R. Dickinson — Chief Engineer - Colin Tuck

A variety of roles have been developed for Pandora II, both with and without the submersible Pisces IV. Her major work was carried out in the western Arctic in support of the Beaufort Sea Project. Other operations included: physics, IOUBC and OAS; biology, EPS, UVic, IOUBC; ecology, BIO; geology, EMR; ocean chemistry, OAS; chlorine tank search, OAS and MOT; tide and current studies, OAS; cable survey, DND.

Heavy Arctic ice conditions, which blocked the normal exit route for Pandora II and her consort Theta, made it necessary to sail out by the eastern route. The return to the west coast was made by way of Halifax and the Panama Canal. This ship is probably the first commercial vessel to circumnavigate the North American continent.

M. V. THETA

Master - K. Maro

Chief Engineer - A. Johannsen

MV Theta was chartered for a second season in support of the Beaufort Sea Project. Like Pandora, she returned by the eastern route to Halifax, her home port. The ships were lucky when the normally ice-blocked Fury and Hecla Straits permitted clear passage down to Foxe Basin and open water. Theta went off charter in Halifax.

PISCES IV

Operations Officer - G. R. Meek

Chief Pilot - I. Sanderson

Pisces IV, our deep-dive submersible, underwent her scheduled major refit and was engaged in numerous research acrivities for scientists and hydrographers. The craft also assisted in the search for the missing chlorine tanks, diving on 'suspect' objects picked up on sonar. The tank cars were not found.

CSL REVISOR

The revisory survey launch Revisor was inactive as hydrographers were engaged in major surveys off the west coast of Vancouver Island.

LAUNCHES

Other hydrographic launches also operated on a less-than-usual scale. CSS Wm. J. Stewart operated some launches during the west coast survey. One of these, Barracuda, capsized when hit by a large breaking wave at the entrance to Barkley Sound. With the greatest of good fortune and good seamanship, all hands survived with only superficial injuries (and probably vivid memories) to mark this traumatic experience. Barracuda also assisted at the search for missing chlorine tank cars earlier in the year.

DEPOT

The Depot workshops facility continued to rebuild and repair the small craft. Depot personnel also gave support to hydrographers and scientists in the form of mechanical construction and services.

MANAGEMENT SERVICES DIVISION

N. A. Todd - Chief of Division

Institute of Ocean Sciences

The introduction to last year's annual report commented on the distractingly audible evidence that progress was being made on the construction of new facilities at Patricia Bay. This year there is considerable visible evidence as well.

The project was inaugurated by The Honourable Jeanne Sauvé, Minister of the Environment, on March 14. At that time there was little to see apart from heavy earth-moving equipment.

Now the workshop-warehouse building has been closed in and contractors are energetically working towards a mid-April completion. This section will house the launch repair and maintenance workshops, central stores and large general warehouse. It will also be the temporary home for the UNIVAC 1106 computer which the region has recently acquired.

Progress has been equally satisfactory on the main building complex. Excavation, underground services, concrete retaining walls and footings are complete and a good start has been made on erection of the structural steel, so that very shortly a skeletal impression of the final form of the buildings will be evident.

The new wharf is almost complete. Structurally everything is in place, awaiting only the final hook-ups and testing of the services.

Some preliminary planning was done on the development of a Marine Technology Centre for the 40-acre parcel of land held by the Department across the West Saanich Road from the Institute. A basic land use study was presented to the mayor and council of North Saanich and a public meeting was held to discuss the subject. One of the primary concerns of the residents of the area is the shortage of water at the north end of the Saanich Peninsula. It was agreed that the proposal to use well water should be tested more fully before proceeding with further plans for the Centre.

Administration

The less dramatic but essential work of providing administrative support is being carried on under increasingly difficult circumstances. With the completion of the Institute one of these difficulties - serving groups so geographically dispersed - will be removed. Administration has had to absorb its share of the recent cut in man-years and this has made the problem more acute.

Since last April the financial records have relied entirely on the computerized system. Certain refinements are still being added to make

it compatible with the in-house Hewlett-Packard.

Plans for developing a materiel management system continue. It is hoped to have a system operating when central stores moves to Patricia Bay early in 1976.

Twelve OAS Pacific Region staff took the French language knowledge examination and all passed at one level or another.

The Library

L. S. Thomson - Librarian

The library was active in 1975 with a 25 per cent increase in the Interlibrary Loans from various sources.

The collection continued to grow at a high rate with the addition of over 700 new titles, but the journals increased by only 6, from 125 to 131. We still have a long way to go to have an adequate collection of journals.

CSS Parizeau passes Fisgard lighthouse as she leaves Esquimalt Harbour to continue hydrographic survey off the west coast of Vancouver Island.

Task Force, Committee and Similar Activities

R. W. Stewart

Advisory Committee on Oceanic Meteorological Research (ACOMR) of WMO

Joint Organizing Committee (JOC) of the Global Atmospheric Research Program (GARP)

Canadian National Scientific Committee for GARP

SCOR - IAMAP - IAPSO Working Group on Air-Sea Interaction

International Council of Scientific Unions (ICSU) - Committee on Space Research (COSPAR) - Canadian delegate

Sea Use Council (Canada-USA) - vice-chairman

Regional Board, Pacific Region (DOE)

Regional Board, Pacific Region, Executive Committee

Regional Board, Western and Northern (DOE)

Canada Advisory Committee on Physics (NRC)

National Research Council of Canada - GARP Grants Advisory Committee

Physical Oceanographic Commission (IAPSO) - president

Beaufort Sea Steering Committee - chairman

Arctic Environmental Steering Committee

Arctic Waters Oil and Gas Advisory Committee

Royal Society of Canada Interdisciplinary Selection Committee

W. N. English

Advisory Board on Marine Technology, B. C. Research Council

Pacific Sub-Committee on Oceanography

Regional Board, Pacific Region (DOE) - alternate

Pacific Region Board Working Group on Abatement of Pollution from DOE Ships - chairman

Regional Board, Pacific Region, Estuary Working Group

Sea Use Council (Canada-USA) - alternate

Military Colleges Advisory Board

Regional Ocean Dumping Advisory Committee

HYDROGRAPHIC DIVISION

Ages, A. B.
- Environmental Emergency Working Group, Victoria Zone
- Coastal Water Pollution Group, Committee on the challenges of modern society, NATO
- Technical committee (DOE), Annacis Island sewage treatment

Bolton, M.
- Canadian Institute of Surveying, Hydrographic Technical Committee - vice-chairman
- National Hydrographic Survey Officers' Appraisal Board
- New Research Vessel Users Design Committee - chairman
- Pacific Sub-Committee on Oceanography of CCO - alternate
- Survey Technology Advisory Committee, BCIT
- Workshop on Offshore Surveys for Mineral Resource Development
- Canadian FGGE Planning Group

Huggett, W. S.
- New Research Vessel Users Design Committee

O'Connor, A. D.
- Canadian Institute of Surveying, Victoria Branch - executive member

Rapatz, W. J.
- B. C. Civil Defense Tsunami Committee
- Ocean Dumping Act - inspector
- Fisheries and Marine Contact - ad hoc task force, Mackenzie Basin Liaison Committee

Sandilands, R. W.
- Hydrographic Technical Committee, Canadian Institute of Surveying
- The Canadian Surveyor - associate editor (hydrography)
- Canadian Hydrographic Association - associate editor
- Survey Technology Advisory Committee, Camosun College
- Workshop Group on Offshore Surveys for Mineral Resource Development
- Board of Trustees, Maritime Museum of B. C. - chairman

Smithers, F. R.
- Public Information Group, DOE Pacific
- Board of Trustees, Maritime Museum of B. C.
- Regional Committee on Interagency Routing of Navigational Information

Watt, J. V.
- Aerial Hydrography Project Sub-Committee of Oceanography working group of CACRS

Wills, R.
- Steering Committee, Environmental Effects Study, Northwestern British Columbia
- Regional Hydrographic Survey Officers' Appraisal Board - chairman
- Regional Committee on Interagency Routing of Navigational Information

OCEAN CHEMISTRY DIVISION

Cretney, W. J.
- Ph.D. Dissertation Committee - D. R. Green at UBC (Hydrocarbons)
- Working Group on Laboratory Waste Disposal, Pacific Region

Wong, C. S.
- Advisory Committee - Geosecs, Carbonate Chemistry Panel
- Advisory Committee - Chemistry, CEPEX
- Coordinating Committee on Environmental Issues, DOE, Pacific Region
- Marine Chemsitry Committee, Fisheries and Mariene Service, Pacific Region - chairman
- National Marine Chemistry (Standard) Group
- Ocean Dumping Technical Committee, Pacific Region
- Ph.D Dissertation Committee - D. R. Green at UBC (hydrocarbons)
- Ph.D. Dissertation Committee - P. Berrang at UVic (lead)

OCEAN PHYSICS DIVISION

Farmer, D.M.
- Babine Lake Steering Committee

Garrett, J. F.
- International Council of Scientific Unions Committee on Space Research (COSPAR), Working Group VI, Panel A (weather and climate)
- Canadian National Committee for Scientific Committee on Oceanic Research

Giovando, L. F.
- DOE Steering Committee re environmental effects of the proposed expansion of Vancouver International Airport
- DOE Steering committee re environmental study of Roberts Bank development
- Working Group on Environmental Baseline Study of the Lower Fraser Valley and Fraser Estuary

Lewis, E. L.
- Panel on Ice. Arctic Oceanography Sub-Committee, Canadian Committee on Oceanography
- Sub-Committee on Snow and Ice of Committee on Geotechnical Research of National Research Council, Ottawa

Nasmyth, P. W.
- IGOSS Group of Experts on Technical Systems Design and Development and Service Requirements - chairman

Tabata, S.
- Ocean Climatic Panel of Working Group 34 of the Scientific Committee on Oceanic Research

Thomson, R. E.
- British Columbia Coordinating Climate Committee

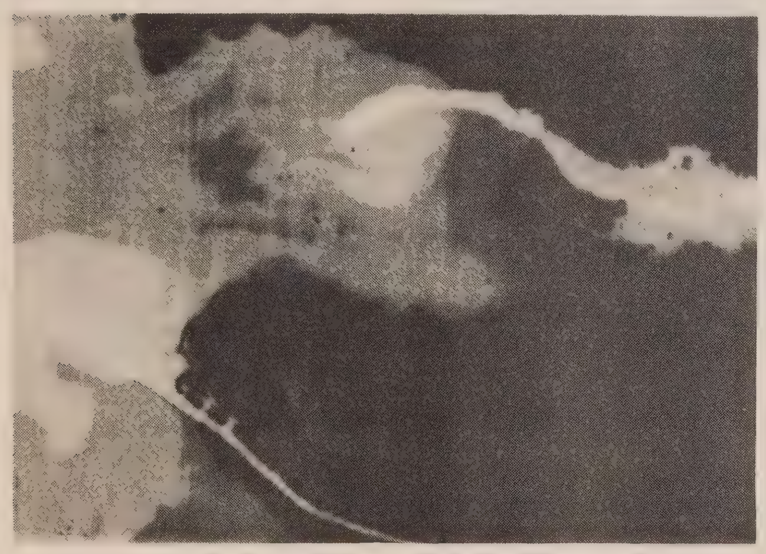
OCEAN ENGINEERING

Teng, K.
West Coast Electronic Data Processing Coordinating Committee, DOE
Canadian Information Processing Society, Victoria Section - program chairman

Johns, R. E.
West Coast Electronic Data Processing Coordinating Committee, DOE

SHIP DIVISION

Geldart, E. N
Pacific Region Resource/Survey Vessel Committee - secretary
Working Group on Abatement of Pollution from DOE Ships - secretary



Thermal scanner imagery is used to map temperature of surface water of Burrard Inlet and Vancouver Harbour.

Pictures taken from a CCRS Falcon jet at 30,000 feet show warmer areas (15°C) as black and colder areas (11°C) as white. Pictures were taken during an ebbing (top) and flooding tide in support of a Burrard Inlet current survey by Tidal and Current Survey Section.

Research and Development Contracts

		Total Amount
1.	Water properties sampling and measurement program aboard CCGS Vancouver at Ocean Station P. *Chemex Labs Ltd., North Vancouver, B.C.*	$ 26,936
2.	*Radar investigation of bird migration along the Beaufort Sea Coast. *LGL Ltd., Edmonton, Alberta.*	71,630
3.	*In depth review study and report related to the interpretation of Beaufort Sea seabird and marine mammal studies. *Donald A. Blood and Associates, Lantzville, B.C.*	19,870
4.	Collection and chemical analysis of Pacific Ocean Water. *Seakem Oceanography Ltd., Victoria,B.C.*	56,578
5.	Fabrication and provision of specialized mechanical equipment for turbulence/microstructure measurement from the Pisces submersible, *University of British Columbia. (Dr. T. R. Osborne, Institute of Oceanography)*	6,475
6.	Study of the problems and existing solutions of oceanic cartography. *Sam Gfeller, Victoria, B.C.*	9,500
7.	Analysis of environmental samples, *Seakem Oceanography Ltd., Victoria, B.C.*	16,261
8.	*Oceanographic measurement in the Beaufort Sea baseline cruise. *Seakem Oceanography Ltd., Victoria, B.C.*	18,364
9.	*Organize and conduct a beach walk and analyse samples in the Beaufort Sea area. *Thalassic Data Ltd., Vancouver, B.C.*	18,789
10.	*Preparation of material for Beaufort Sea technical, scientific and overview reports. *R. J. Childerhose, Victoria, B.C.*	40,700
11.	Controlled environment pollution experiment to provide biological identification in sampling oil pollution materials in B.C. coastal waters. *University of British Columbia, Vancouver, B.C. (Dr. T. R. Parsons, Department of Biology)*	5,203

12.	*Study on the long-term fate of oil in the environment. *W. Richardson, Victoria, B.C.*	2,250
13.	*Physical oceanographic study of the Beaufort Sea *Seakem Oceanography Ltd., Victoria, B.C.*	10,979
14.	*Physical oceanographic study of the Beaufort Sea *Case Existological Laboratories Ltd., Victoria, B.C.*	16,622
15.	*Taxonomic studies of zooplankton from the Beaufort Sea. *Catherine Grohe, Dollard des Ormeaux, Quebec.*	4,600
16.	Analysis of Seawater for alkalinity and carbon-dioxide. *Seakem Oceanography Ltd., Victoria, B.C.*	3,600
17.	*Research into the ecology and oil biodegradation potential of arctic marine and fresh waters. *Fay Pilkington, Dollard des Ormeaux, Quebec.*	4,375
18.	*Research on the physiological ecology and the effects of crude oils on Arctic marine inverterbrates. *Trudy C. Mullin, Sennerville, Quebec.*	6,236
19.	*Taxonomic studies of phytoplankton samples and specimens from the Beaufort Sea. *M. Foy, Ste. Genevieve, Quebec.*	6,055
20.	*Beaufort Sea near-surface current survey. *Dobrocky Seatech Ltd., Victoria, B.C.*	6,429
21.	Analysis and experimental measurements of ocean surface current observations and moored current data from various Pacific coast locations. *University of British Columbia. (Dr. G.D. Pond, Institute of Oceanography)*	13,310
22.	*Processing of Beaufort Sea Oceanographic Data and modifying existing programs. *Seakem Oceanographic Ltd., Victoria, B.C.*	3,700
23.	Development, design and supply of stabilizing fins for the Pisces IV submersible, *Canadian Aircraft Products Ltd., Richmond, B.C.*	45,630
24.	*Field studies and analysis of marine fauna from the Beaufort Sea and adjacent waters. *D. Galbraith, Ste. Anne de Bellevue, Quebec.*	8,000
25.	Wind tunnel experiments of Pisces IV. *G.V. Parkinson, Vancouver, B.C.*	240

26.	Study of mixing processes in Georgia Strait. *University of British Columbia, Vancouver, B.C. (Dr. P. LeBlond, Institute of Oceanography)*	9,138
27.	*To investigate the effects of entrainment and emulsification of crude oil in Arctic Sea ice. *Norcor Engineering and Research Ltd, Yellowknife, N.W.T.*	54,070
28.	Analysis of lighthouse oceanographic data. *I. Webster, West Vancouver, B.C.*	5,100
29.	Oceanographic measurement program to determine horizontal distribution of physical characteristics of ocean water at different depths. *F. Hartley, Victoria, B.C.*	1,350
30.	Computer software and analysis of remote sensing data. *D. Traux, Victoria, B.C.*	16,200
31.	Computer analysis of hydrographic data. *D. Traux, Victoria,B.C.*	700
32.	Testing of polargraphic techniques for trace metals in seawater. *Dr. J. Piuze, Victoria, B.C.*	3,290
33.	Provision of computer programs and analysis of oceanographic data. *Case Existological Labs, Victoria, B.C.*	49,294
34.	Hand correction of hydrographic charts. *Case Existological Labs, Victoria, B.C.*	40,869
35.	Analysis of tidal and current data obtained in harbours and estuaries. *A. Harrison, Victoria, B.C.*	1,340
36.	*Collaboration in preparation of final Beaufort Sea reports. *H.E.A. Nichol, Sidney, B.C.*	1,998
37.	*Collecting Beaufort Sea Oceanographic and Meteorological Data. *C. Wallace, Brentwood Bay, B.C.*	1,500
38.	Preparation of First GARP Global Experiment (FGGE) buoy array development plan, *Beak Consultants Ltd., Richmond, B.C.*	19,302
39.	Study of existing and historical ocean dumping sites in the Pacific region. *A. B. Wards, Abbotsford, B.C.*	4,935
40.	Study of behavior and response of benthic organisms to ocean dumping. *B. Chang, Vancouver, B.C.*	5,100

41.	Study of existing ocean dumping technology. *Beak Consultants Ltd., Richmond, B.C.*	10,500
42.	*Computer analysis of oceanographic data for the Beaufort Sea project. *L. Landry, Victoria, B.C.*	375
43.	Application of differential pulse polargraphic technique to air-sea interface studies. *Dr. P.S. Liss, School of Environmental Sciences, University of East Anglia, Norwich, England.*	8,000
44.	Development and construction of an oceanographic water sampler. *Seakem Oceanography Ltd., Victoria, B.C.*	12,896
45.	Service to assist in setting up Nuclide SV-90 mass spectrometer and in developing working procedures for isotopic dilation technique. *P. Berrang, Victoria, B.C.*	8,000
46.	Radio carbon measurement on carbonate samples. *Dr. A. D. McIntyre, B.C. Research Council, Vancouver, B.C.*	2,880
47.	Computer software development to modify and extend U/W Focal and the PDP8/e computer. *J. Van Zee, University of Washington, Seattle, U.S.A.*	4,000
48.	Computer software development to modify and extend U/W Focal, Version II. *J. Van Zee, University of Washington, Seattle, U.S.A.*	500
49.	Professional services in support of Aerial Hydrography, project. *Department of Engineering, University of New Brunswick, Fredericton, N.B.*	3,000
50.	Participation in the development of a system for processing of photogrammetric and inertial navigation system data as required for the Aerial Hydrography Project. *Dr. S. E. Nasry, University of New Brunswick, Fredericton, N.B.*	5,000
51.	Assembly of a file on computer compatible magnetic tape of all the available bathythermograph data from the north-east Pacific. *Alan G. Law, Victoria, B.C.*	640
52.	*Investigation of the characteristics and behavior of a rising oil/gas plume in ice covered waters. *Dr. D. R. Topham, Victoria, B.C.*	22,500
53.	*Provision of a consultant and advisory services on statistical methods of analysis of data on sea ice cover and topography and its application to containment of oil by sea ice. *P. Wadhams, Victoria, B.C.*	3,600

54.	*Investigation of movement of oil under sea ice. *Imperial Oil Ltd., Calgary, Alberta.*	10,000
55.	Analysis of slabs from frozen cores obtained in the southern Strait of Georgia. *Chemex Labs, N. Vancouver, B.C.*	2,244
56.	Chemical analysis of seawater, particulates and sediments in the southern Strait of Georgia. *Seakem Oceanography Ltd., Victoria, B.C.*	25,363
57.	Study and tracking of the dispersion of dumped materials *Dobrocky Seatech Ltd., Victoria, B.C.*	21,360
58.	Study of the release of trace metals from dumped material in seawater. *Seakem Oceanography Ltd., Victoria, B.C.*	4,567
59.	Photographic documentation of benthic organisms and habitats at dump sites in the southern Strait of Georgia. *Dobrocky Seatech Ltd., Victoria, B.C.*	2,286
60.	Sorting of benthic samples from disused millsites. *Beak Consultants Ltd., Richmond, B.C.*	3,668
61.	Sampling of seawater, particulates and undisturbed sediments in the southern Strait of Georgia. *Dobrocky Seatech Ltd., Victoria, B.C.*	17,864
62.	Identification of benthic samples from disused mill sites, *National Museum, Ottawa, Ontario.*	1,500

NOTE

1. Contracts marked * form part of the Beaufort Sea Project.
2. Contracts 39 to 41 and 54 to 62 come under the Regional Ocean Dumping program.

Publications

Institute of Ocean Sciences, Patricia Bay, 1974 Annual Report

Bell, W. H., 1975: The Howe Sound current metering program. Vols. 1-3. Pacific Marine Science Report 75-7

Bellegay, R., B. L. Twaites, T. A. Smythe and C. de Jong, 1975: Oceanographic observations at ocean station P (50°N, 145°W), Volume 63. Pacific Marine Science Report 75-4

Cox, B. K., and C. de Jong, 1975: Oceanographic observations at ocean station P (50°N, 145°W), Volume 61. Pacific Marine Science Report 75-4

Farmer, D. M. and D. Lemon, 1975: Dispersion of dyed sea-water discharged from moving vessels. Pacific Marine Science Report 75-3

Farmer, D. M. and L. A. F. Spearing, 1975: Isotherm plots of Babine Lake during the ice-free season, 1972-73. Pacific Marine Science Report 75-9

Farmer, D. M., 1975: Potential temperatures in deep freshwater lakes. Limnology and Oceanography, 20.

Farmer, D. M., 1975: Penetrative convection in the absence of mean shear. Quarterly Journal of the Royal Meteorological Society, 101

Gargett, A. E., 1975: Horizontal coherence of oceanic temperature structure. Deep-Sea Research, December.

Gower, J. F. R., 1975: Uses of aircraft and balloon photography in studying coastal areas. Pacific Marine Science Report 75-8

Gower, J. F. R., 1975: Priorities for remote sensing in oceanography. Canada Centre for Remote Sensing Report.

Hughes, G. C. and A. B. Ages, 1975: Salinity and temperature measurements in the lower Fraser River, 1966-1973. Pacific Marine Science Report 75-2

Marko, J. R. and R. E. Thomson, 1975: Spatially periodic lead patterns in the Canada Basin sea ice; A possible relationship to planetary waves. Geophysical Research Letters, (10)

Milne, A. R., 1975: Beaufort Sea and Mackenzie Delta environmental studies. Canadian Society of Petroleum Geologists, 821-827, May.

Minkley, B., and C. de Jong, 1975: Oceanographic observations at ocean station P (50°N, 145°W), Volume 62, September 13 - October 30, 1974. Pacific Marine Science Report 75-5

Tabata, S., 1975: Status of Oceanographic knowledge of the continental shelf and ocean waters off the Pacific Coast of Canada. Proceedings of workshop sponsored by the Pacific Subcommittee on Oceanography, Canadian Committee on Oceanography, April 17-18, 1975, Victoria B.C.

Thomson, R. E., 1975: Longshore current generation by internal waves in the Strait of Georgia. Canadian Journal of Earth Sciences 12 (3), 472-488.

Thomson, R. E., 1975: The propagation of planetary waves over a random topography. Journal of Fluid Mechanics 70 (2), 267-285

Thomson, R. E., 1975: The attenuation of vertically propagating internal gravity waves in a randomly varying wind/current shear. Journal of the Atmospheric Sciences, in press.

Thomson, R. E., 1975: Waves. Pacific Yachting 9 (3)

Thomson, R. E. 1975: The Strait of Georgia; Tides and Currents, Part 1. Pacific Yachting 9 (4)

Thomson, R. E., 1975: The Strait of Georgia; Tides and Currents, Part 2. Pacific Yachting 9 (5)

Thomson, R. E., 1975: The Strait of Georgia; Tides and Currents, Part 3. Pacific Yachting, 10 (1)

Thomson, R. E., 1975: Currents in the Strait of Juan de Fuca. Pacific Yachting, 10 (2)

Thomson, R. E., 1975: Inlets, Sills, Tidelines and Temperatures. Pacific Yachting, 10 (5)

Thomson, R. E., 1975: Upwelling - Bringing cold water to the surface. (Pacific Yachting, 11 (1)

Topham, D. R., 1975: Hydrodynamics of a sea bottom oil well blowout. Beaufort Sea Technical Report #33

Wadhams, P., 1975: Airborne laser profiling of swell in an open ice field. Journal of Geophysical Research 80 (33) 4520-4538

Wadhams, P., 1975: Sea ice morphology in the Beaufort Sea. Beaufort Sea Technical Report #36

Walker, E. R., 1957: Oil, ice and climate in the Beaufort Sea. Beaufort Sea Technical Report #35.

Wong, C. S., and R. W. Macdonald, 1975: Factors incluencing the degree of saturation of gases in sea water. American Electrochemical Society monograph, 214-232.

DIRECTOR GENERAL

Stewart, R.W.; B.Sc., MSc., (Queen's), Ph.D. (Cantab), FRSC, FRS, D.Sc. (McGill), LL.D. (Dalhousie)

DEPUTY DIRECTOR GENERAL

English, W.N.; B.A. (Brit.Col.), Ph.D. (California)

MANAGEMENT SERVICES DIVISION

Todd, N.A.; B.S. (Glasgow), M.A. (Carleton); Chief of Division

Aavik, J.F.
Craton, M.I.K.
Crouch, R.W.
Doyle, D.A.
Egan, L.L.
Firth, C.
Foote, S.B.
Gravel, J.N.
Hall, E.J.
Hogg, W.
Lohrmann, B.; B.A., B.Sc., M.Sc. (Guelph)
Lohse, P.
Mackenzie, R.M.D
Martyn, B.T.
Moulson, S.A.
Oswald, P.E.
Parsons, J.E.
Peirson, E.
Reinstein, H.G.
Sabourin, J.T.
Smith, D.C.
Smith, G.R.; B.A.Sc.(ME) (Brit.Col.) P.Eng
Thomas, C.D
Thomson, L.S.C.; B.A..(Saskatchewan) B.L.S. (Brit.Col.)
Van Dusen, T.S.
Wakefield, L.M.
*Zwolinsky, V.

*Left during 1975

Permanent Staff

Bolton, M.; Regional Hydrographer

Ages, A.B.; B.A.Sc., M.A.SC. (Brit.Col.), P.Eng.
*Ames, S.E.
*Anderson, N.M.: B.Sc.(Victoria) Dip. AIT
Bell, R.D.
Bennett, K.M.
Brown, R.E.
Browning, P.C.
Carracedo, C.
Chivas, J. W. ; Master, F.G.
Clark, D.J.
Coldham, F.A.
Coldwell, J.H.
Cooke, R.A.
Coulter, E.M.
Curran, T.A.; B.A.Sc.(EE) (Brit.Col.) P.Eng
Czotter, K.L.; Dip. BCIT
Eaton, G.H.; Dip. BCIT
Farmer, M.
Fujino, N.S.; DIP BCIT
Galloway, J.L.; B.A.Sc. (EE) M.A.SC.(EE) (Brit.Col.), P.Eng.
Osbourne, M.; Cert. (T.I.)
Patton, M.M.
Philp, A.R.
Pickell, L.M.
Pierce, R.A.
Plume, T.C.
Popejoy, R.D.
Preece, M.L.; Dip. BCIT

Rapatz, W.J.; B.Sc. (Victoria)
Raymond, A.R.; Dip. Algonquin College
Richardson, G.E.
Ryan, C.F.; Dip. RRE (England)
Sandilands, R.W.; Lt. RN (Rtd)
Shoenrank, R.U.; B.Sc. (Victoria)
Smithers, F.R.

Gregson, D.J.; Dip. BCIT

Harris, W.J.
Hermiston, F.V.
Hinds, E.W.; Dip. BCIT
*Hlina, R.C. Dip. BCIT
Holman, K.R.
Huggett, W.S.; Master, F.G.
Johnson, R.W.
*Jones, T.L.; Master, F.G.
Josephson, K.G.
Korhonen, R.K.
Larkin, J.B., B.Sc. (P.E.I.)
Loshiavo, R.; Dip. BCIT
Lusk, B.M.; 350 T
Lyon, A.G.

May, R.I.D.; Dip.BCIT
Milner, P.R.; Dip. BCIT
Mortimer, A.R.; Master, F.G.
Muse, R.A.; Trade Cert. CAF
Nast, C.J.
O'Connor, A.D.; Master, H.T. (U.K.) 350T

Stephenson, F.E.; B.Sc. (Victoria)
Tamasi, C.R.; Dip. BCIT
Taylor, M.S.
Taylor, W.R.; Dip. RCC
Thompson, L.G.
Wanamaker, J.G.; Dip. BCIT
Watt, B.M.
Watt, J.V.; B.A.Sc.(EE) (Brit.Col,), P.Eng.
Wigen, S.O.; B.A.Sc. (Brit.Col.) P.Eng.

Wills, R.; Master, F.G.
Wood, D.J. Dip. BCIT
Woods, M.V.; Dip. BCIT
*Young, V.N.
*Young, W.

*Left during 1975

OCEAN CHEMISTRY DIVISION

Wong, C.S.; B.Sc., M.Sc. (Hong Kong), Ph.D. (Scripps), Dip. Mar. Sc. (UNESCO), MCIC, FRIC; Chief of Division

Bellegay, R.D.; Dip. NAIT, Ass. Deg. in Oceanography (Shoreline Community College, Seattle)
*Cornford, A.B.; B.Sc. (McMaster), Ph.D. (Brit.Col.)
Cretney, W.J.; B.Sc., Ph.D. (Brit.Col)
Jackson, C.M.; B.Sc. (Victoria)
Johnson, W. K.; Dip. BCIT
Macdonald, R.W.; B.Sc.(Dalhousie), Ph.D. (Dalhousie)

COMPUTING SERVICES

Butcher, J.W.; B.Sc. (Victoria), M.Sc. (Toronto)
Douglas, A.N.; B.Sc. (Victoria)
Johns, R.E.; B.Sc. (Victoria), M.Sc. (Brit.Col.)
Page, J.S.; B.Sc. (Brit.Col.)
*Morgan, C.G.; B.Sc., M.Sc. (Alberta)
Richards, P.J.; B.Sc. (Brit.Col.)
Smith, D.B.; B.Sc. (Victoria)
Teng, K.; B.A.Sc., M.A. (Brit.Col)
Woollard, A.L.; B.Sc. (Victoria)

OCEAN PHYSICS DIVISION

Nasmyth, P.W.; B.A.Sc., M.A., Ph.D. (Brit.Col.); Chief of Division

Bell, W. H.; B.A.Sc. (Brit.Col.), M.Sc. (Hawaii), P.Eng.
Bigham, R.H.
Chase, G.W.; Dip. BCIT
Crean, P.B.; B.Sc. (Dublin), M.A.Sc. (Toronto), Ph.D. (Liverpool)
De Jong, C.
Farmer, D.M.; B.Com., M.Sc. (McGill), Ph.D. (Brit.Col.)
Garrett, J.F.; B.A. (Harvard), Ph.D. (Brit.Col.)
Giovando, L.F.; B.A., M.A., Ph.D. (Brit.Col.)
Gower, J.F.R.; B.A., M.A., Ph.D. (Cantab)
Herlinveaux, R.H.
Kamitakahara, G.R.; B.Sc. (Toronto)
Koppel, A.W.
Kuwahara, L.S.C. ; B.Sc. (Brit. Col.)
Lake, R.A.; B.Sc. (Brit.Col.), M.Sc. (Washington)
Lewis, E.L.; B.Sc., M.Sc., Ph.D. (London)
*Marles, E.W.; B.Sc. (Victoria)
Meikle, J.H.
Milne, A.R.; B.A.Sc. (Toronto), M.Sc. (McGill)
Minkley, B.G.; Dip. BCIT
Moody, A.E.
Moorhouse, S.W.

Perkin, R.G.: B.A.Sc., M.Sc. (Brit.Col.)
Henry, R.F.; B.Sc. (Edinburgh), Ph.D. (Cantab)
Richards, D.L.
Sieberg, D.G.; Dip. (VVI)
Spearing, L.A.F.; B.Sc. (Brit.Col.)
Stickland, J.A.
Stucchi, D.J.; B.Sc. (York), M.Sc. (Dalhousie)
Sudar, R. B.; B.A.Sc. (Toronto)
Tabata, S.; B.A., M.A. (Brit.Col.), D.Sc. (Tokyo)
Teichrob, R.C.; Dip. BCIT
Thomson, R.E.; B.Sc., Ph.D. (Brit.Col.)
Walker, E. R.; B.Sc. (Manitoba, M.A. (Toronto), Ph.D. (McGill)
Wallace, J.S.

*Left during 1975

SHIP DIVISION

Geldart, E.N.	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Regional Marine Superintendent
Green, F.S.	Master Mariner; Assistant Marine Superintendent (deck)
Marr, D.	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Assistant Marine Superintendent (Engineering)
Keene, R.W.	Master, F.G. (X); Relief Master
Bradbury, J.D.	Depot Supervisor
Chan, C.C.	Engineer 1st Class Motor; Relief Engineer

CSS PARIZEAU

Chamberlain, A.G.	Master, F.G.; Master
Fisher, E.G.	Master, F.G.; 1st Officer
Archibald, D.	2nd Mate, F.G.; 2nd Officer
Christie, J.N.	Radio Certificate; W/O
Clarke, L.E.	Supply Officer
Parkinson, R.	Engineer 1st Class Combined; Chief Engineer
Kyle, R.G.	Engineer 2nd Class Motor; Senior Engineer
Orr-Hood, J.	Engineer 4th Class Motor; 2nd Engineer

CSS Wm. J. Stewart

Sjoholm, K.J.	Master, F.G.; Master
Easson, R.J.	Master, F.G.; 1st Officer
Barboza, C.S.	Mate, F.G.; 2nd Officer (Deceased)
Palmer, S.	Supply Officer

Henderson, J.D.	Engineer 2nd Class Steam; Chief Engineer
Gibson, R.B.	Engineer 3rd Class Steam; Senior Engineer
Bateman, S.P.	Engineer 3rd Class Combined; 1st Engineer
Conway, A.	Engineer 4th Class Combined; 2nd Engineer

CSS VECTOR

Marston, J.C.	Master, F.G.; Master
Shaw, B.	Master, H.T.; 1st Officer
Bishop, S.O.	Mate, H.T.; 2nd Officer
Clouston, G.	Engineer 3rd Class Motor, Chief Engineer (deceased)
Peet, J.	Engineer 3rd Class Motor, Chief Engineer
Storer, T.H.	Engineer 3rd Class Motor, 1st Engineer
Pearson, R.	Engineer 4th Class Motor; 2nd Engineer

CSS RICHARDSON

Wheeler, M.G.	Master, 350 T; Master
Henderson, J.N.	Engineer 4th Class Motor; Chief Engineer

CFAV LAYMORE

Dyer, M.J.	Master
Doherty, H.R.	Chief Engineer

MV RADIUM EXPRESS

O'Sullivan, J.	Master
Butler, W.	Chief Engineer

MV PANDORA II (Charter)

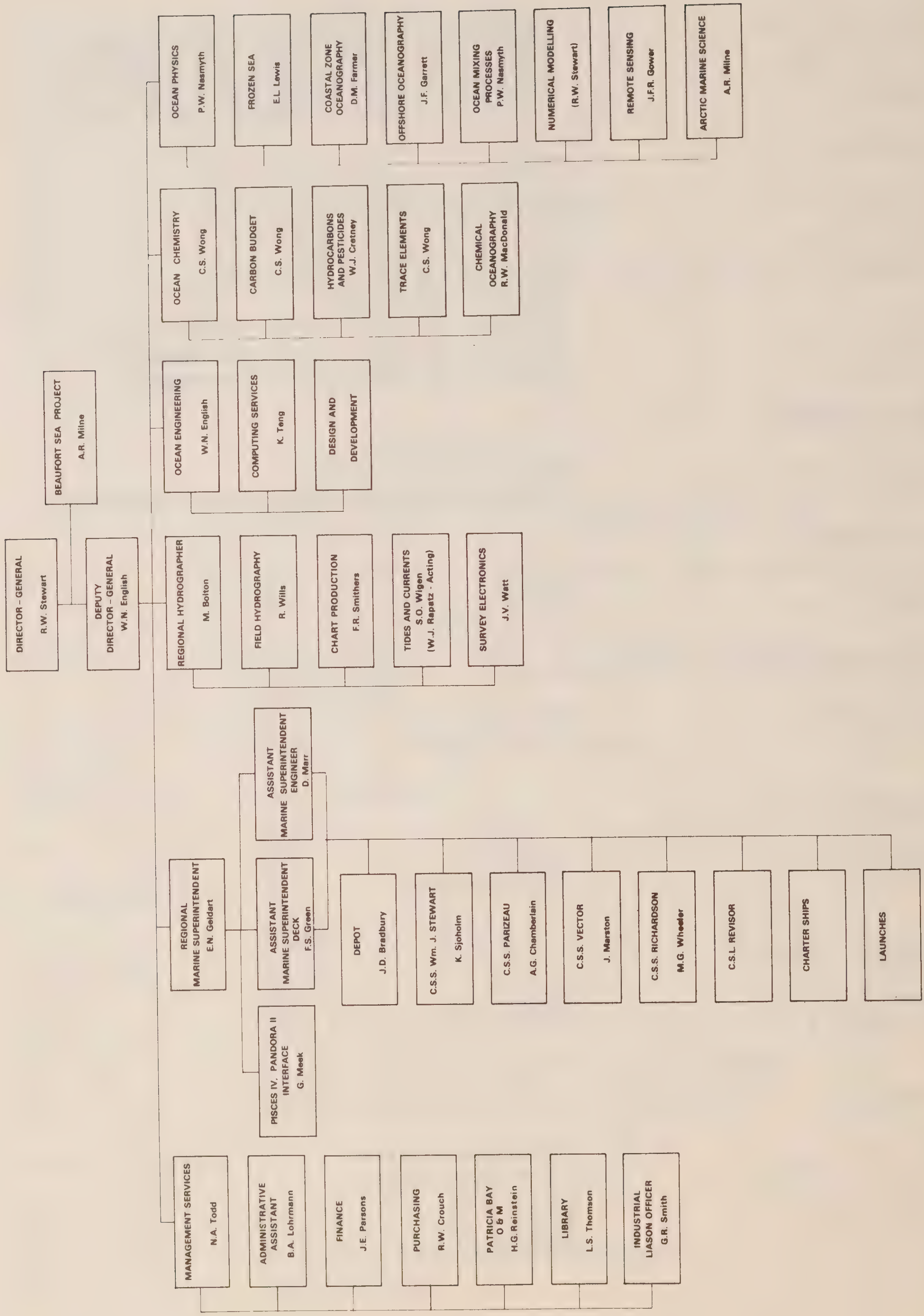
Dickinson, R.	Master
Tuck, C.	Chief Engineer

MV THETA (Charter)

Marko, K.	Master
Johannsen, A.	Chief Engineer

PISCES IV

Meek, G.R.	Operations Officer
Sanderson, Capt. I.	Chief Pilot (DND)
Homer, G.M.	Pilot
Taylor, R.H.	Pilot
Witcombe, A.E.	Pilot


DIRECTOR - GENERAL
R.W. Stewart
BEAUFORT SEA PROJECT
A.R. Milne
DEPUTY DIRECTOR - GENERAL
W.N. English
OCEAN PHYSICS
P.W. Nasmyth
FROZEN SEA
E.L. Lewis
COASTAL ZONE OCEANOGRAPHY
D.M. Farmer
OFFSHORE OCEANOGRAPHY
J.F. Garrett
OCEAN MIXING PROCESSES
P.W. Nasmyth
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REMOTE SENSING
J.F.R. Gower
ARCTIC MARINE SCIENCE
A.R. Milne
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C.S. Wong
CARBON BUDGET
C.S. Wong
HYDROCARBONS AND PESTICIDES
W.J. Cretney
TRACE ELEMENTS
C.S. Wong
CHEMICAL OCEANOGRAPHY
R.W. MacDonald
OCEAN ENGINEERING
W.N. English
COMPUTING SERVICES
K. Teng
DESIGN AND DEVELOPMENT
REGIONAL HYDROGRAPHER
M. Bolton
FIELD HYDROGRAPHY
R. Wills
CHART PRODUCTION
F.R. Smithers
TIDES AND CURRENTS
S.O. Wigen
(W.J. Rapatz - Acting)
SURVEY ELECTRONICS
J.V. Watt
REGIONAL MARINE SUPERINTENDENT
E.N. Goldart
ASSISTANT MARINE SUPERINTENDENT ENGINEER
D. Marr
ASSISTANT MARINE SUPERINTENDENT DECK
F.S. Green
PISCES IV, PANDORA II INTERFACE
G. Meek
DEPOT
J.D. Bradbury
C.S.S. Wm. J. STEWART
K. Sjoholm
C.S.S. PARIZEAU
A.G. Chamberlain
C.S.S. VECTOR
J. Marston
C.S.S. RICHARDSON
M.G. Wheeler
C.S.L. REVISOR
CHARTER SHIPS
LAUNCHES
MANAGEMENT SERVICES
N.A. Todd
ADMINISTRATIVE ASSISTANT
B.A. Lohrmann
FINANCE
J.E. Parsons
PURCHASING
R.W. Crouch
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G.R. Smith

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT — 1976

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY
Victoria, B.C.

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INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT 1976

VICTORIA, B.C.

APRIL, 1977

INTRODUCTION

As is the case for all years, 1976 saw its successes and its disappointments, its appointmemnts and retirements. Perhaps most notable of the successes is the progress in the construction of our new Institute at Patricia Bay. The dock area and the depot building surrounding the old hangar have now been completed and are occupied permanently by stores and personnel of Ship Division, and temporarily by other groups awaiting completion of the main building.

Because of accurate judgment of the probability of labour disputes in the construction industry during 1976, and fairly accurate judgment of the intensity and duration of these disputes, it has proved possible to keep quite closely to planned construction and cash-flow schedules. Although we have suffered some cost over-runs, these are very minor compared with those of some other construction projects in the country.

It is anticipated that a major section of the new building housing Ocean Physics and, later, a substantial portion of Hydrography, will be occupied in May, 1977. As the building comes off paper and takes form as glass and concrete and carpets, it continues to give the impression that it will be an attractive and effective place in which to work. The site is of course magnificent - even inspirational. We must trust that, after the first blush, not <u>too</u> much time will be spent admiring the view. My personal experience from other places where I have worked leads me to believe that this will not in fact be a problem.

The major disappointment of the year was the failure of CSS Parizeau to get into the Beaufort Sea. In her attempt to round Point Barrow and the north coast of Alaska, she encountered heavy multi-year ice which impeded her progress for many days and eventually caused such damage to both propellors that the summer's operation had to be abandoned. In the end she was brought back to Victoria by the Canadian Forces tug St. Anthony, which performed this long tow with great efficiency. The loss of the year's hydrographic work in the western Arctic was a severe blow, following as it did two years when hydrographic studies of the area were deliberately forsaken in favour of the oceanographic program of the Beaufort Sea Project.

The Hydrographic Division responded quickly and efficiently to this extended loss of our major ship. Although they were unable to attempt any work in the Amundsen Gulf, which was Parizeau's destination, shore-based launch operations were rapidly expanded and a substantial quantity of valuable hydrographic work was performed in British Columbia coastal waters.

Although not perhaps in the category of a disappointment, since we were never led to expect better, the increasingly tight restrictions on man-years and on money, together with increasing demands for our services, continue to keep our operations under the greatest of strain.

Although some things have been improved by increased efficiency, and we confidently expect further efficiencies when we move together into our new Institute, the level of service and support available to our professionals is unquestionably decreasing.

Of retirements, none compares in impact and significance with that of Dr. W. N. English, Deputy Director-General. Dr. English has a wealth of experience gained in a variety of posts in the Canadian Federal Government. He knew how the system worked, and he got things done. Those of us who worked with him learned a lot from him and we will continue to get things done. The organization of the Institute of Ocean Sciences has always been designed to suit the people here, rather than the other way round. The post of deputy director-general was established to accomodate Dr. English's abilities. With his retirement the post will not be filled. His duities will be covered by a re-distribution of responsibilities amongst other members of the staff.

Almost of the nature of a retirement has been the decision not to reactivate the William J. Stewart for the field season of 1976. The continuing squeeze on financial and man-year resources made it impossible for us to return her to service. She is a fine old ship, attractive to the eye and comfortable to sail in. It hurts to see her idle, but we could do no other. The cost of support of all kinds has increased markedly in the past few years and the most effective use of resources appears to be to hold or even increase our professional staff while accepting a decrease in support.

Some notable acquisitions and appointments have taken place. The decentralization policy in the Hydrographic Service has led to an increase in our local chart production capability, at the expense of that in Ottawa. We have been able to make a start on our long-planned Ocean Ecology Laboratory although, under conditions of restraint, it may be many years before it achieves the size that the importance of the work warrants. Two people from the Pacific Environment Institute were transferred to us, adding strength to our chemistry effort. We have expanded our large-scale air-sea interaction program, and in particular our attempts to develop an understanding of the influence of the ocean on weather and climate. In the same move we have very much tightened our relationship with U.S. groups working on the same problem, particularly in the NORPAX program.

Readers familiar with our annual reports may find the following pages somewhat more philosophical in their tone than is customary. This is a spin-off from an examination of Departmental programs which is being undertaken within the framework of a "Zero A-Base Review". I have considered it useful that some of the material prepared for this review should be included in the 1976 Annual Report.

R. W. Stewart

HYDROGRAPHIC DIVISION

M. Bolton - Regional Hydrographer

The primary objective of the Hydrographic Division of the Institute of Ocean Sciences is to provide accurate and timely bathymetric and navigational information. This information, published in the form of nautical charts, tide tables and Sailing Directions, is made available to various users, including commercial shipping, fishermen, and recreational boaters. Pertinent data are provided for other federal government agencies, engineering and consulting firms, universities, environmental groups and the general public. The Division is operationally responsible for integrated geophysical-hydrographic surveys of the continental slope and margin.

The past year has demanded the utmost in flexibility and adaptability from Hydrography. The decision taken late in 1975 to lay up CSS William J. Stewart, the ice damage suffered by CSS Parizeau in July 1976 and the increased impetus of the decentralization (or regionalization) of the chart production process were three major factors influencing the 1976 program.

The lack of major ship time forced an increase in shore party activities, which had to be restricted to southern British Columbia waters. The disabling of CSS Parizeau wiped out the planned Amundsen Gulf program. The regionalization of chart production increased staff through man-year transfers from Ottawa, while creating severe production and training pressures. These should be alleviated in 1977 as the Chart Projection Section adapts to the increased workload and new staff become more proficient.

Mr. S.O. Wigen, Regional Tidal Superintendent, continued for a second year as Associate Director of the International Tsunami Information Center in Honolulu. Mr. W.J. Rapatz continued as Acting Superintendent.

Major programs for 1977 have required a considerable planning effort. They will include extensive calibration of the Pacific Coast Loran-C radio navigation chain; detailed bathymetric and tidal current surveys in the seaward approaches to Kitimat in connection with the development of a possible tanker terminal in Kitimat; continuation of the disrupted western Arctic charting program and a major re-survey of Vancouver Harbour.

FIELD HYDROGRAPHY SECTION

R. Wills - Regional Field Superintendent

F.A. Coldham	R.D. Popejoy
K.C. Czotter	M.L. Preece
G.H. Eaton	L.E. Prussner
*N.S. Fujino	A.R. Raymond
J.B. Larkin	G.E. Richardson
B.M. Lusk	R.U. Schoenrank
R.I.D. May	C.R. Tamasi
P.R. Milner	*K.H. Waller
A.R. Mortimer	J.G. Wanamaker
A.D. O'Connor	D.J. Woods
R.A. Pierce	M.V. Woods

*Left during 1976.

R.W. Sandilands - i/c Sailing Directions
J.W. Chivas
L.M. Wakefield

J.B. Larkin - i/c Hydrographic Development
+A.D. O'Connor
+G.H. Eaton
+A.R. Raymond
A.J. D'Aoust (at CCRS Ottawa)

+Rotational staff on Hydrographic Development

This Section is responsible for all hydrographic field operations in the Pacific Region (British Columbia, Athabasca-Mackenzie Waterway, Western Arctic) and includes Hydrographic Development and Sailing Directions.

The CSS William J. Stewart was not available to the Hydrographic Service in 1976 with the result that increased use was made of shore-based launch parties, operating in southern British Columbia waters. Hydrographic surveys of Nanoose Bay, Ucluelet Harbour, Nanaimo Harbour, Becher Bay, Malaspina Inlet and Saanich Inlet were completed. Further work was done in Barkley Sound, including Pipestem and Effingham Inlets. A survey of Sabine Channel in the Strait of Georgia was 80 per cent completed. Control and photo-identification work was carried out in the Vancouver Harbour area in connection with plots to be prepared for 1977 surveys. A minor large-scale survey was completed at Victoria to augment earlier Victoria Harbour and Trial Islands surveys.

The CSS Parizeau, with B.M. Lusk as hydrographer-in-charge, continued hydrographic and geophysical surveys northward along the continental margin of Vancouver Island, closing the gap between 1975 work and 1973 surveys of Queen Charlotte Sound. In July Gebco lines were run en route to the western Arctic but the ship suffered ice damage off

Point Barrow and was unable to reach the survey area.

Revisory work, employing mainly the launch Revisor, with A.R. Mortimer as hydrographer-in-charge, covered the Vancouver Island coastline and adjacent mainland coastlines as far north as Rivers Inlet. A field contract was let for the first time to undertake chart revision work, and to update Sailing Directions, on the mainland coast north of Queen Charlotte Sound. This proved to be a most successful and economical operation and a considerable amount of useful information was obtained.

On the Athabasca-Mackenzie Waterway the main task of the charter vessel Radium Express, with M.V. Woods as hydrographer-in-charge, was a survey of the navigation channel through Eskimo Lakes from Liverpool Bay to Hans Bay, the proposed site of a new natural gas plant. Gulf Oil Limited provided considerable support and assistance on this project. The survey of Mackenzie Bay was completed and new surveys were conducted in Kittigazuit Bay, at Hay River, and from mile 90 to mile 140, chart 6407.

Preparations are underway for the calibration of the Loran-C positioning system mentioned earlier. Reconnaissance trips were made to the transmitter sites at Williams Lake and George, Washington. Mr. A.R. Mortimer is in charge of this project.

Sailing Directions

The tenth edition of B.C. Sailing Directions, (South Portion), Volume 1, was received from the printers in December. Revision of the B.C. Sailing Directions (North Portion), Volume II, and Small Craft Guide, Volume II, is in hand for 1977 publication.

The third edition of Small Craft Guide, Volume I, is expected in January 1977. The limits of this publication have been extended to include Port Alberni to Sooke and Nanaimo to Campbell River. In conjunction with Small Craft Guide, Volume II, coverage for small craft is now extended to the southern waters where the majority of recreational boating takes place in British Columbia.

Compilation of a gazetteer of local place names containing approximately 2,000 local and superseded names has been compiled for limited distribution for Canadian Hydrographic Service and Air Sea Rescue use. Canadian Coast Guard authorities report that this cross index of local to official place names has been of great value in rescue incidents where the vessel in distress has identified its position only by reference to a name in local use. A cooperative program with the Canadian Coast Guard cutters on coastal patrol was initiated which resulted in the receipt of valuable data for revision purposes.

Hydrographic Development

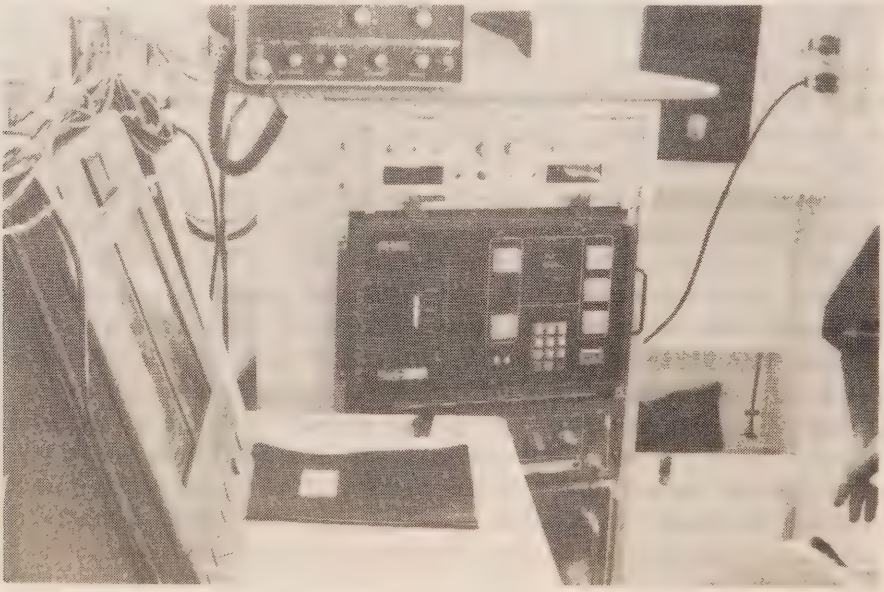
The Aerial Hydrography Project on shallow water surveying continued at Canada Centre for Remote Sensing. Final flight tests are anticipated by the fall of 1977.

Four Portable Hydrographic Acquisition Systems (PHAS) units were delivered, and preliminary testing was carried out in the northern portion of Saanich Inlet. Units were sent to the other Regions for evaluation, and the system was used on local surveys done after CSS Parizeau returned from the Arctic. PHAS will be fully operational for the coming field season.

Specifications were prepared for a suitable winch, tow cable and attachments for using side-scan sonar from CSS Richardson. After thorough evaluation, the system is now in routine operation and has proved extremely useful. Since it is on a small but seaworthy vessel, it is available at short notice without disrupting the schedule of the larger ships.

Investigations were conducted into wind-powered battery charging sources to relieve logistic support of microwave positioning transponders at remote sites. The performance of an unsolicited proposal contract to demonstrate BOSUN sonar sounding techniques in Juan de Fuca Strait was monitored.

Support was provided to various groups, including positioning for scientists monitoring ocean dumping sites in the Strait of Georgia; positioning and control for MOT personnel altering sector lights at Kootenay Lake; and completion of the field training portion of the 1975/76 Hydrography I course for Pacific Region candidates.



The new Portable Hydrographic Acquisition System (PHAS) was installed in the launch Jaeger for field trials in Saanich Inlet.

TIDAL AND CURRENT SURVEY SECTION

S.O. Wigen - Regional Tidal Superintendent
W.J. Rapatz - Acting Regional Tidal Superintendent

A.B. Ages - i/c Hydraulic Research	F.E. Stephenson - i/c Tidal Survey
A.L. Woollard (Computing Services)	R.E. Brown
W.S. Huggett - i/c Current Surveys	C.C. Carracedo
A.N. Douglas (Computing Services)	D.E. Hilder
W.J. Harris	A.C. Ma
J.J. Manson	*L.E. Ponse
F.V. Hermiston	A.J. Smedley
M.J. Woodward	*W. Tario

*Left in 1976

As an integral part of the Canadian Hydrographic Service, the Tidal and Current Survey Section provides the mariner with tidal and current information essential for safe navigation. It also provides data for and interacts with the coastal zone, offshore and Arctic oceanographic sections, in various oceanographic studies.

The Hydraulic Research Unit further improved its numerical models of the Fraser River estuary, the approaches to Vancouver Harbour and Burrard Inlet. The models provide navigational information and also information on water levels and on the diffusion of pollutants in the lower reaches of the Fraser River. A field program on the behaviour of the 'salt wedge' in the main arm of the Fraser was carried out in cooperation with the Water Survey of Canada and the Department of Public Works. Further development of oil spill tracking methods was carried out.

Three major tidal and current surveys were carried out, in Haro Strait, Johnstone Strait and the approaches to the Fraser River, the latter two being a continuation of previous surveys. Oceanographic personnel participated in the surveys and many temperature and salinity profiles as well as current meter records were obtained. The data will be used in the definition of tidal streams and currents in the interest of safe navigation, as well as for studies of oceanographic processes as discussed in the oceanographic part of this report.

Tidal and current survey operations were carried out in the Mackenzie River and in the Western Arctic. These surveys provided datums for hydrographic charting in the Eskimo Lakes and Mackenzie Delta, field information for storm surge and tidal prediction in the Beaufort Sea, and 205 days of current information for ice movement prediction in the vicinity of Herschel Island. The demand for tidal information in the Western Arctic is increasing, and dual air/water pressure gauges were installed at Tuktoyaktuk, Cape Parry and Cambridge Bay which it is hoped will provide a continuous year-long record of tidal level at the three locations. As part of a modest continuing study of tidal processes in the north-east Pacific, the submersible Pisces IV was used to look for tide gauges installed for us by USA agencies on Bowie Seamount and Cobb Seamount. The Bowie search was

successful and an invaluable 416 days of open ocean tidal data was recovered. The extreme tidal range over this seamount was 4.0 meters, four times what was expected.

All instrumentation for the temporary and tsunami-warning tide gauge stations was maintained, overhauled, repaired and distributed from the Section's workshop. The field data from 23 stations (permanent, temporary and tsunami-warning) and from 25 gauges operated by field hydrographic parties, was processed, yielding over 300 months of tidal data.

A very considerable effort has been devoted to the reading, editing and compiling in improved format of data tapes and other current and tidal records. This has made available new information for the three volumes of Tide and Current Tables for which the Institute is responsible and which have now all been updated.

Mean daily positions of satellite tracked drifting buoys launched Dec. 13, 1975. One mark corresponds to each day. The buoys are attached to drogues suspended at a depth of 20 metres. Their mean direction of motion changes several times during the period, indicating changes in current patterns. Although most of the buoys lost their drogues through a weakness in design, the most easterly retained its drogue for 95 days.

CHART CONSTRUCTION SECTION

F.R. Smithers - Regional Chart Superintendent

R. Bell	K. Holman	R. Pierce
K. Bennett	R. Johnson	A. Philp
P. Browning	K. Josephson	*T. Plume
*P. Buckley	R. Korhonen	M. Taylor
G. Chan	B. Kynoch	L. Thompson
D. Clark	A. Lyon	*J. Underwood
E. Coulter	C. Nast	*J. Unti
D. Dobson	G. Neilson	*K. Vaino
E. Earl	M. Patton	B. Watt
M. Farmer	*K. Peterson	*V. Young
D.L. Fisher	L. Pickell	*W. Young
M. Hohl		

*Left in 1976

During 1976 the Chart Construction Section moved towards establishing a total package for the production of nautical charts in the Region. With the exception of 10 metric format charts of the Gulf Islands now being produced in Ottawa, all compilation, drafting, printing, correction and distribution of Pacific Coast, Western Arctic and Athabasca-Mackenzie Waterway charts is done locally. Hydrographic headquarters in Ottawa retains quality control and approval for release of charts.

This development has been possible through a transfer of man-years and personnel from headquarters. Nine positions were reallocated, with an additional three to be transferred over the next two years. Understandably some growing pains were experienced during the transition. Problems with contract chart printing centred around colour densities as some inconsistencies in the tone of buffs and blues were experienced. These appear to be resolved, while the cooperation and service from the printer continue to be first rate.

During the summer the processing of both new editions and reprints lagged behind the demand for charts and several 'out-of-stock' situations developed. The critical factors were old or damaged reproduction material, which had to be rescribed, and the relative inexperience of some of the staff. Neither factor should apply in 1977.

The following statistics give some indication of the work accomplished:

*New editions	9	Charts distributed	158,567
*Reprints	32	Publications distributed	64,096
*New charts	2	Dealers inspected	40
Notices to Mariners	115	Dealers established	23
Chart patches	23	Dealers withdrawn	18
Chart corrections	1,300,065	**MAREPS processed	324

*Includes compilation, drafting and printing.
**MAREP - Marine Reporting System established in cooperation with Canadian Power Squadrons.

Because of manpower limitations and the heavy workload, the Section temporarily discontinued the provision of graphic arts services in the Institute. The same constraints precluded participation in displays or

SURVEY ELECTRONICS SECTION

J.V. Watt - Head

W.R. Taylor - Head, Technical Support
R.A. Cooke (with Frozen Sea Research)
L.W. Dorosh
D.G. Gregson
E.W. Hinds
R. Loschiavo
R.A. Muse
M. Osborne
C.F. Ryan
T.J. Soutar (with Ocean Chemistry)

T.A. Curran - Electronics Engineering
J.L. Galloway - Electronics Engineering

The Section provides electronics engineering and technical support for survey, research and ship operations in the Region. The demand for these services continues to grow each year as the amount and sophistication of electronic equipment in use increases. The resources of the Section were severely strained in 1976, and it was only possible to provide technical support, at a minimal level, to major cruises. Planned maintenance has been drastically reduced, with an inevitable future increase in down time, and the technical back-up to the electronics engineering effort has been well below optimum. Despite these difficulties substantial progress has been made in up-grading the electronic systems used for regional survey and research.

Engineering Support

A significant amount of engineering effort went to supporting Field Hydrography following the delivery of the new Portable Hydrographic Acquisition System (PHAS), which is based on a micro-processor and is lighter, more compact and more reliable than earlier systems. The support involved acceptance tests, field trials, test equipment, interfacing and software.

Paper studies were carried out on echogram optimization, contouring, automatic plotting and depth digitization, to meet regional needs. A project on the recovery of valuable Arctic data from a very poor quality tide gauge recording resulted in the development and construction of a highly refined reader for Aanderaa tapes. Some minor projects in support of oceanographic programs were the development and construction of a computer to multi-channel strip chart recorder interface, a camera timer and an engineering study of data returns from a drift buoy experiment.

Technical Support

1976 field activities included provision of technical support aboard both charter and government ships, and ashore, at a variety of sites, in support of a number of shore-based hydrographic survey parties. In addition the group successfully modified and set up a Mini-fix chain in the Rho-Rho mode and performed the modifications necessary to operate, for the first time, an Innerspace 408 digitizer in a programming mode. Other significant actifities included a study of radio communication problems from Victoria to Point Barrow; development of plans for more effective mobile electronics support for shore-based field parties and preparation for the 1977 Loran-C calibration operation. New field equipment such as the PHAS acquisition system, an EPC graphic recorder, a 5 km, ±1 meter accuracy, Trisponder system, new microprocessor based Omega and Loran-C positioning system receivers and an Innerspace 412 depth digitizer have added spice to the maintenance and installation diet during 1976.

J. Love, D. Smith and T. Curran with Aanderaa tape translation system. Data, recorded in coded form in submerged instruments, is read from recovered tapes and translated into computer compatible format for processing.

OCEANOGRAPHIC DIVISIONS

The oceanographic activities of the Institute are in three ocean areas: coastal, deep sea and Arctic. The paragraphs which follow discuss the factors which have shaped the Institute's program in these areas.

The present day reasons for studying the ocean are to describe ocean systems, - physical, chemical and biological, and to define ocean processes and reactions in order to understand and evaluate the effects, direct and indirect, of the ocean on human activities and the impact of human activities on ocean systems. One might include scientific curiosity, and this has, indeed, been a significant reason for much of the oceanographic research which has been done in the past. In these times of economic restraint and limited resources, however, very little oceanography is done out of curiosity alone. There are too many pressing, practical problems demanding attention, - problems associated with the extraction of ocean resources, - renewable and non-renewable, the effects of coastal engineering developments on the marine environment and on fisheries and wildlife habitats, deliberate dumping and/or accidental spillage of pollutants, navigation, transportation, recreation, and a host of other human activities which interact with or are affected by the ocean directly or in secondary ways.

Coastal Oceanography

It is in the coastal area where the most varied and most intensive interactions between man and the sea take place, and it is in this area that a very large proportion of the available effort is expended on investigations of immediate practical importance. Industrial developments and engineering activities involving coastline modification are in conflict with fisheries interests. Domestic and industrial wastes entering coastal waters through sewer or river systems interact with local ecosystems and may affect human health through direct recreational contact with the water or through the food chain. Underwater cables and pipelines may pose a threat to marine life in case of leaks or breakage, and their positioning and design must take into account bottom material and configuration and the stresses imposed by water currents.

In case of accidental spillage of potentially dangerous or noxious materials - particularly oil, and particularly in populated areas or areas of special ecological concern - it is necessary to understand surface current patterns and the effect of local winds on surface drift in order that the movement of spilled material can be predicted and countermeasures planned for maximum effectiveness, and it may be necessary to have a knowledge of deep currents and mixing and diffusion processes in order to assess the potential hazards from dissolved or suspended materials. It is

necessary also to recognize and understand natural trends or changes in the marine environment. Not only may these themselves affect biological productivity and/or the harvesting of fisheries resources, but failure to account for natural changes can lead to complete misinterpretation of observations in terms of the influence of man.

Recognizing the importance of and limitations in supply of coastal ocean resources, and recognizing existing and potential conflicts between the many diverse users of coastal waters it has become necessary to establish management procedures and controls to reconcile and arbitrate amongst the multiple demands on the ocean system, to take account of continuing increase in human population in coastal areas, and to allow continuing industrial expansion without unacceptable degradation of the marine environment or its resources. To, firstly, recognize and define real or potential problems in any of the subject areas referred to and, secondly, attempt to find solutions or acceptable compromises, it is necessary to understand water currents and circulation patterns, mixing and diffusion processes, temperature variations, water mass origin and distribution, chemical baselines, the pathways and fate of pollutants and aspects of local ecosystems at lower trophic levels. It is to gain knowledge of these and related subjects that our Coastal Oceanography program is designed.

Limitations in available resources place severe restrictions on the scope of programs which can be undertaken. Areas for work are selected according to national and regional priorities, modified according to shifting pressures of the moment, although flexibility is limited by the inherent nature and variability of the ocean. It may take one to three years to develop a reasonable understanding of a particular area, and longer to define long term trends on which future planning should be based. To some degree economic or political pressures which may shift with shorter time scales must be resisted if we are to make efficient use of the limited resources available.

The most cost-effective use of public funds in coastal oceanography necessitates a balance between seeking longer term scientific goals that have general application in coastal waters and a task-force like attack on specific urgent problems. Longer term programs permit the development of a sound physical understanding of processes likely to be encountered in specific locations and also lead to the development of strong scientific capability among the individuals involved. Urgent practical problems are then much more effectively tackled by making use of this scientific expertise which has been allowed to develop with longer term projects.

Deep Sea Oceanography

Most major institutions carrying out oceanography regard deep sea oceanography as the centre of their operations. However, the oceanic area for which the Institute of Ocean Sciences is responsible is so large, and the resources available to it are so limited, that this is not the case for

IOS. Most of the effort of the Institute is concentrated on coastal waters. Nevertheless, a significant offshore effort is maintained. Resources employed are kept to a minimum by using situations of opportunity and by cooperating with American groups working in our geographic area. An appreciable amount of effort is employed in seeking ways of obtaining data more cost-effective than the dispatching of expensive well equipped research ships into the open Pacific.

The outstanding situation of opportunity on the west coast is the existence of the weatherships "Vancouver" and "Quadra" operating out of Esquimalt to Station "P" at Latitude 50°N Longitude 145°W. The primary mission of these ships is meteorological. Substantial oceanographic programs can be mounted from them for minimal additional cost. A great deal of our deep sea oceanography is built around this opportunity.

Deep sea oceanography is carried out at IOS for the following motivations:

1. Generalized oceanic pollution: The northeast Pacific contains the oldest water in the world in the sense of the water which was least recently in contact with the surface. It is also the water of the northern hemisphere which is least subject to the direct influence of man, and therefore a very important baseline area in considering the general health of the ocean. Since the world's oceans are connected and water circulates more or less freely among all oceans, materials such as radioactive wastes, petroleum hydrocarbons and PCBs introduced into the ocean at any point on the globe may eventually affect Canadian ability to use ocean resources such as fish. The topics requiring investigation are oceanic circulation, oceanic mixing and the chemistry of potential pollutants which could increase or decrease concentrations and availability. It is also important to determine as well as possible the present condition of the ocean so as to be able to detect deterioration or amelioration. It is important to recognize that if the ocean as a whole becomes polluted in some subtle but biologically important way, the volume involved is so great that remedial action may be difficult to the point of being impossible.

2. Climate: Several of the theories purporting to account for climatic fluctuations give a prominent role to variations in temperature of the northest Pacific. Canada, as a northern country, is very vulnerable to the effects of climatic fluctuations and it is important that the Canadian government scientists be able to offer the best possible advice on the probable evolution of climate and the possibility of predicting climate change.

   Most of the solar energy reaching the earth is absorbed in the oceans as heat since the oceans cover 75% of the earth's surface and since the atmosphere is practically transparent. Horizontal differences in the ocean surface temperature associated with varying insolation between polar and tropical regions but modified

by the ocean circulation lead to horizontal temperature differences in the overlying atmosphere, leading in turn to atmospheric circulations. However the winds associated with the atmospheric circulation control the oceanic circulation and hence in turn the availability of heat to drive the atmospheric circulation. The ocean also acts as a reservoir or buffer for other substances which can potentially affect the atmospheric circulation and hence the climate, such as carbon dioxide and water. Variations in the ocean can lead to changes in the atmospheric circulation, affecting the weather and climate.

Because of its geographical situation, the Canadian economy is sensitive to climate trends in the areas of energy production and consumption, agriculture, forestry, and all occupations involving work outdoors. It is thus important to have the earliest possible information and advice on possible climate variations so as to permit effective planning. Important problem areas are ocean response to atmospheric inputs, atmospheric circulation response to oceanic conditions, chemical storage of carbon dioxide, and historical climatology.

One major Institute activity is the maintenance of the oceanographic time series at Ocean Weather Station "P". It is impossible to detect variations or trends in climate without long records. The series of observations from Station "P" was begun in 1954, and is one of the two or three longest systematic series of mid ocean observations available. A comparatively recent addition to this series is the measurement of the carbon dioxide content of the air and water. The air measurement clearly show the steady increase hitherto only seen from land stations, and provides conclusive evidence that the phenomenon is global and that the ocean is not able to absorb carbon dioxide rapidly enough to lead to reduced fluctuations over the sea. The sampling is presently carried out by commercial concerns under contract, leading to a significant increase of the oceanographic capabilities of the private sector.

3. Interaction of deep sea and coastal waters: It has become evident that a great many of the things observed in coastal waters, which influence such coastal phenomena as the flushing of pollutants and the environment of fish, are very strongly determined by events occurring in the deep sea. These coastal phenomena will never be understood or made predictable without a deeper understanding of what is occurring in the deep ocean.

Generally speaking coastal waters are a mixture of offshore ocean water with water from coastal rivers. To some extent the properties and behaviour of coastal waters are controlled by local influences, meteorological or otherwise, but variations in the offshore waters making up the largest part of the mixture cannot be neglected. Neither can dynamic influences originating in the deep ocean. (The tides are the most obvious of these influences, but there are a

host of other, more subtle, types of waves which propagate into inshore waters and greatly complicate our attempts to understand what goes on in these waters). This is particularly true in more open areas, such as the water of the continental shelf, or Queen Charlotte Sound, Hecate Strait and Dixon Entrance. Thus in order to obtain the understanding of coastal processes necessary for fisheries management and pollution control it is necessary to have an understanding of the variability of adjacent offshore waters. In addition to the problem of observing and describing the character and behaviour of the offshore waters, a special problem area exists because the effects of rapid changes in depth, as over the continental slope, radically alter the possible dynamics and lead to much greater variability along the coast than would otherwise be possible.

Arctic Oceanography

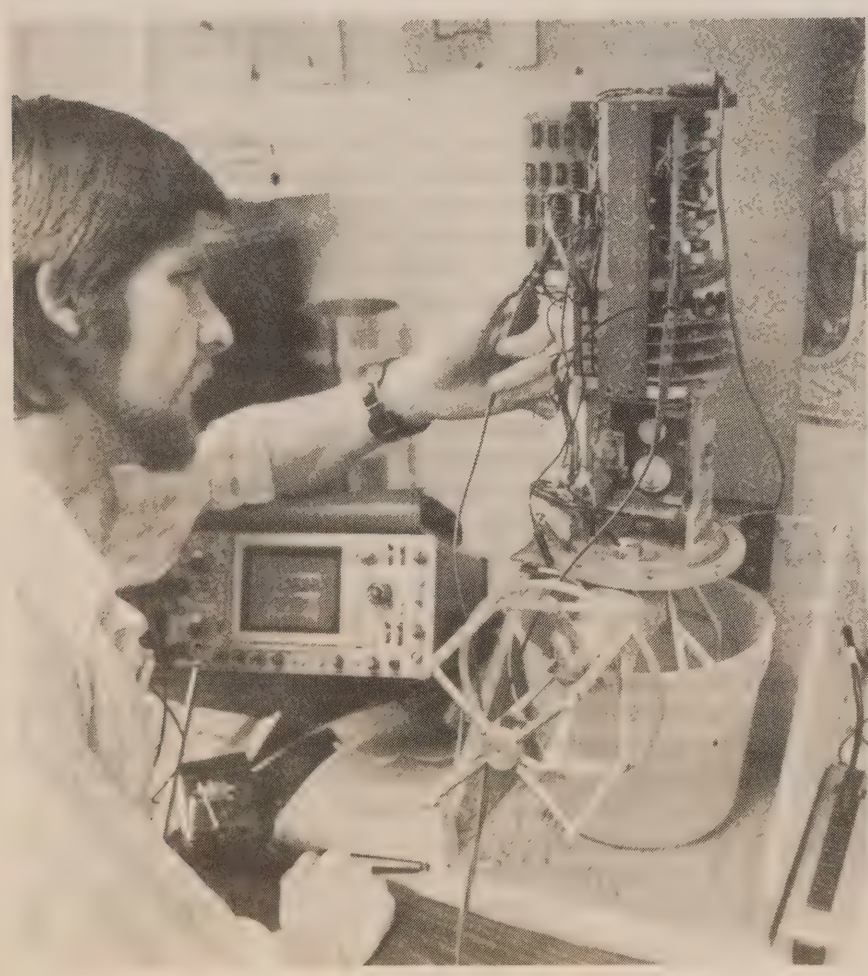
Petroleum and natural gas offshore exploration is taking place in the Beaufort Sea and the Sverdrup Basin. Drilling could take place in Lancaster Sound, on the Baffin Island Shelf, Davis Strait and Cumberland Sound in a few years' time. The waters supporting these activities will form the barriers as well as the routes through which the energy yielded by the sea bottom will reach markets to the south. These waters can also become the recipients of tailings from mines and form the pathways and boundaries for spilled oil. The seasonally and geographically variable sea-ice forms part of the boundary separating the waters from the atmosphere and has as much to do with defining the locations of high biological productivity as does the presence of nutrients in the water itself.

The oceanography of Arctic waters is a key element in the overall management of human activities in the Canadian high Arctic. Water transports nutrients which are needed to nourish biota at the base of the food chain. Water also transports pollutants such as heavy metals and toxic chemicals and emulsified and dissolved hydrocarbons. Sea-ice can herd floating oil, and surface currents spread oil. Water and ice thus importantly influence the destination of pollutants and their concentrations which must be known to assess possible damage to wildlife. In the design of offshore drilling systems, currents in the water column determine marine riser stresses; also should a sub-sea blowout occur, these currents will determine the distribution of oil at the surface. Water movements through the islands of the archipelago permit persistent polynyas or open water areas to exist. Their importance biologically and their role in possibly concentrating oil pollution is unknown.

Investigations in Arctic oceanography relate directly to legislative responsibilities in accordance with the Arctic Waters Pollution Prevention Act and the Ocean Dumping Control Regulations. It is in defining operating conditions and assessing the consequences of non-compliance or

accidents that the main difficulties exist relating to the adequacy of oceanographic information. Even though the industry must take a large responsibility for environmental observations, the regulatory function of Government requires that Government officials have both knowledge and expertise relevant to Arctic oceanography. This region takes the major responsibility for determining physical oceanographic conditions in relation to drilling permits in the Arctic.

Historically, Arctic oceanography, with few exceptions, has been conducted on an opportunity basis with a resulting emphasis on locations accessible by ice breaker and on measurement spanning short time intervals. These features have imposed such limitations on measurements that they have yielded little information other than informed guesses on water mass movements and their variability relative to atmospheric driving forces. We have reached the stage of knowing where and what to measure next in the process of developing a working hypothesis of water movement -- at least in the archipelago. However, the required measurements have not yet been taken. Until they have, and have been analysed, our information will remain rudimentary.



Acoustic current meter, used by Coastal Zone Oceanography Section, undergoing laboratory testing.

OCEAN CHEMISTRY DIVISION

C.S. Wong - Chief of Division
W.J. Cretney - Head, Marine Hydrocarbons
R.W. Macdonald - Head, Chemical Oceanography

R.D. Bellegay - Station P coordinator
C.M. Jackson
W.K. Johnson
F.A. McLaughlin
P.S. Munro - CEPEX coordinator
J.S. Page (Computing Services)
D.W. Paton
J.A.J. Thompson - Heavy metals pollution

P.A. Christensen (NRC Postdoctoral Fellow)
K. Kremling (Visiting Scientist, Institut für Meereskunde, University of Kiel, F.R.G.)
E. Matsumoto (NRC Postdoctoral Fellow, from Geological Survey of Japan)
J. Piuze (NRC Postdoctoral Fellow to March 31, then on secondment from Fisheries Management, Quebec Region)

The Ocean Chemistry Division's primary responsibility is to understand the chemical state of marine waters in areas of concern, and to assess the chemical effects of human activities on the water, the suspended matter and the bottom sediments. These effects must be distinguished from large natural and often non-systematic variations. A secondary role is to provide chemical oceanographic information useful in fisheries research, and in the study of water transport and mixing.

Analysis has continued of the information obtained in 1975 in the Beaufort Sea. Considerable effort has been devoted to problems of the British Columbia coastal zone. The new ocean dumping legislation has drawn attention to the need to understand how dumped materials disperse, settle and interact with the environment. Response has included chemical studies of ocean dumping problems with a concentrated field program at the Point Grey dumpsite. In collaboration with EPS, extensive use has been made of the submersible Pisces IV for the examination of dump sites.

Another program is aimed at understanding the distribution and variability of chemical pollutants in the open ocean, acquiring knowledge of the major transport paths, interactions between the living and non-living reservoirs, estimating the natural anthropogenic fluxes and determining the relevant chemical reactions, so as to enable a very rough prediction on the capability of the ocean to cope with increasing human activities. The principal effort in 1976 was a careful series of measurements made from the weatherships at Ocean Weather Station "P" to obtain an indication of the

variability of pollutant concentrations and also to test new techniques of chemical analysis. Due to the fact that extremely small concentrations of many pollutants may affect marine resources or their utilization, some effort has to be devoted to development of methods to detect reliably minute concentrations of pollutants in sea water or in marine organisms.

Marine Carbon Budget

(Wong, Bellegay, Munro, Jackson, Page)

Efforts to document the increase in background atmospheric CO_2 over the ocean are now in their eighth year at Ocean Weather Station "P" (50°N, 145°W). Weekly air samples were collected on the weatherships CCGS "Quadra" and CCGS "Vancouver" and analyzed in our infrared CO_2 laboratory, which also performed air CO_2 analysis and reference gas calibrations for other Canadian CO_2 stations, at Sable Island in the Atlantic and at Alert in the Canadian Arctic, manned by the Atmospheric Environment Service. Continuous air CO_2 records by infrared analysis on the weatherships were started in April 1976, and the time series, both from flask samples and from continuous chart recording, form an important data base for our understanding of the global carbon budget.

Concern over the effect of increasing CO_2 has been expressed from two points of view. The first concern is the possible impact on climate. No work is being done on climatic modelling in OAS Pacific, but close contact is maintained with groups doing such work, particularly in the United States. The other concern is over the acidity of sea water, where fears have been expressed that the increased acidity which will accompany increased carbon dioxide could have serious effects on the ocean ecology. These questions are very important for such policy decisions as to whether our future energy needs should be met by nuclear power or by burning fossil fuels. (The former has its own environmental dangers, but does not add to the CO_2 tension in the atmosphere).

The atmospheric CO_2 increase over the ocean amounts to about one part per million per year from our Station "P" time series. This represents only about half of the total yearly input from burning of fossil fuels such as gas, oil and coal for home-heating and industrial activities. The rest, one-third to one-half of the total input into the atmosphere, is absorbed either by ocean or the biosphere. These absorption processes are very complex and are poorly known at present. Carbonate chemistry of the surface mixed layer, global oceanic circulation and marine organic carbon cycle have to be considered. Thus, at Station "P", times series are also studied for carbonate chemistry, partial pressure of CO_2, carbon isotope ratio and radiocarbon in the surface waters and the marine atmosphere.

The effect of the marine biosphere on the CO_2 cycle is being studied using a ¼ scale CEE[1] enclosing 60,000 litres of seawater, covered by a specially constructed plastic dome to simulate a simple air-sea system. The pH of the enclosed 'ocean' was adjusted to 7.2, an upper limit pH value in the year 2070 when maximum release of fossil fuel CO_2 is expected, and the control was at pH 8.2 in seawater under natural carbonate chemistry conditions. Another bag was adjusted to 7.2 but with free exchange with the atmosphere in the natural state. Water samples were analyzed for phosphate, nitrate, silicate, chlorophyll, carbon productivity, plankton biomass, pH at 25°C, alkalinity, total CO_2, carbon isotope ratios, particulate organic carbon, dissolved organic carbon, temperature, salinity and detritus carbon. The plastic dome was damaged shortly after the first week by a storm, but the experiment was salvaged by observations on the open CO_2 bag acidified to pH 7.2.

The preliminary results this year indicated that in experiments where nutrients were injected the low pH bags showed a time lag of one to two days in both the increase of photosynthetic activity and the increase in the biomass of plankton (indicated by the Chlorophyll-a content in seawater). This result is similar to what was observed in 1975 in a bag adjusted to a pH of 7.6. The low pH seems thus to have some effect, but apparently not a catastrophic one.

Chlorine cloud released into the atmosphere through an accident in the FMC plant at Squamish

Marine Hydrocarbons

(Cretney, Christensen, Macdonald, Wong, McLaughlin)

The objective of the program is to understand the occurrence, pathways and fate of hydrocarbons (natural, petroleum-based and halogenated) in the marine environment. The main effort in 1976 was on analysis of samples of seawater, sediments and marine organisms collected during the Pandora II cruise in Southern Beaufort Sea last year, and on the production of reports both on the baseline levels of hydrocarbons in the Southern Beaufort Sea, and the distribution of tar and other particulate pollutants along the Beaufort Sea coast and offshore islands.

[1]"Controlled Ecosystem Enclosure"; see discussion of CEPEX which follows.

The baseline studies showed that the present-day Beaufort Sea is very clean with respect to petroleum pollution. The extremely low concentrations of polycyclic aromatic hydrocarbons in seawater and marine organisms required great care in work-up, inside clean rooms, of environmental samples collected in the 1975 cruise. The levels of polycyclic aromatic hydrocarbons in Beaufort Sea seawater are low, comparable to those of uncontaminated seawater in the N.E. Pacific Ocean. The levels of low-molecular weight hydrocarbons, with the exception of natural methane from sediment, are low or close to the detectable limits indicating the absence of petrogenic inputs. The hydrocarbons in fish suggest marginal presence of petroleum hydrocarbons in the tissues. The hydrocarbons in marine sediments show characteristics typical of a mixture of marine and terrestrial hydrocarbons, suggesting the influx of terrestrial plant material via the Mackenzie River, which also flows through areas with known natural seepage and petroleum drilling activity.

Survey of the Beaufort Sea coast of Mackenzie Bay, the western portion of the Tuktoyaktuk Peninsula, the Yukon coast and the offshore islands of the Mackenzie River delta again indicated a very clean environment with respect to tar pollution. No natural seepage was evident, although some isolated occurrences of asphalt near Drift Point and grease near Shingle Point and around Tuft Point and Warren Point were encountered. Plastic wastes, in particular explosive cannister fragments originating from marine seismic activities, were prevalent and were found to have re-inundated beaches that were cleaned up during the 1975 survey.

A new analytical technique has been developed by the Division using a combination of a PROMIN (Programmable multiple-ion monitor) method and an isotopic dilution concept, for use of the Finnigan 3300E gas chromatograph/mass spectrometer system. This technique eliminates difficulties in other methods due to preferential loss through workup of one component compared to the other and discrepancies due to difference in the response to the analysis method between the standard and the compound being analyzed.

The concept of fluorescent extractable compounds (FEC) was investigated to determine its significance in hydrocarbon studies. Our Beaufort Sea work indicates that the FEC in seawater can be a combination of both polycyclic aromatic hydrocarbons (PAH) and non-PAH compounds which fluoresce. An inverse relationship between PAH or FEC and salinity was also deduced from the Beaufort Sea data, suggesting that the source of much of this material was inland, transported by the Mackenzie River.

To meet the stringent requirements of obtaining samples which are not contaminated in the taking, a trace hydrocarbon sampler, made of only Teflon and stainless steel, was developed on contract through an unsolicited proposal by Seakem Oceanography Ltd. under supervision of Ocean Chemistry Division. The sampler is capable of full protection of the sample walls and the sample on passage through the surface microlayer.

Trace Metals

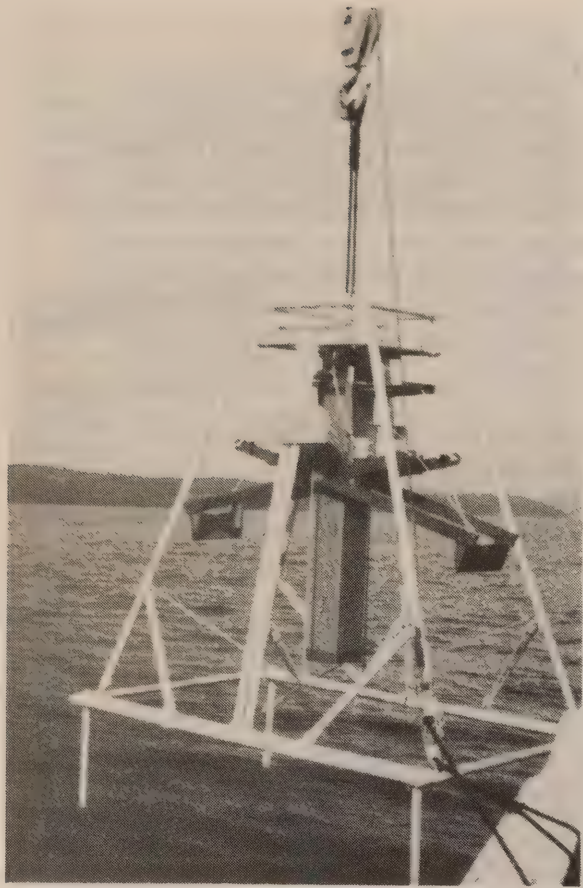
(Wong, Kremling, Piuze, Matsumoto, Macdonald, Johnson)

The main objective of this program is to assess the natural and anthropogenic inputs of physiologically significant trace metals into the marine environment and their interactions with the marine biota and sediments. For seawater, the key problem is the reliability of the sampling and analysis of trace metals at the sub-parts per billion level. There is also the problem of trace metal detection and chemical species identification in a complex biological matrix, and of the assessment of physiological significance at such low metal levels. For marine sediments, the mobilization and fluxes of metals are the important factors for understanding the behavior and pathways of metal contaminants in ocean management problems.

The ubiquitous presence of lead aerosols in the air has caused serious unreliability in lead determinations. Thus, the study of the levels of lead in the environment requires extreme care in every step of sample collection, handling, work-up and analysis to ensure that the sample is not contaminated during or after collection. Using very special techniques, the levels of lead and other heavy metals in the Strait of Georgia have been measured in connection with the ocean dumping project. Preliminary results indicate much lower values for dissolved metal concentrations than previously obtained. Lead levels, by flameless atomic absorption, were 0.03-0.7 μg/kg. Lead by mass spectrometry was 0.04-0.27. Other metal levels determined were cadmium, 0.01-0.07 μg/kg; copper, 0.1-1.4; zinc 0.3-3.3; mercury 0.0-0.07.

In response to an urgent concern regarding mercury levels in the north, Ocean Chemistry conducted a crash program to analyze the plankton, fish and surface sediment samples collected during the 1975 Beaufort Sea cruise, and accelerated the processing of shipboard data on seawater mercury levels. The seawater and surface sediment in the southern Beaufort Sea were found to have values of mercury lower than any reported in the literature, averaging about 11 ng/l of seawater and about 67 ng/g dry weight of surface sediments. The fish, Cisco species, had a mercury level of about 50 ng/g dry weight. The plankton, with about 900 ng/g dry weight, appeared to be high relative to reported oceanic values.

The dumping ground off Point Grey near the estuary of the Fraser River is the largest dumpsite in Canada for disposal of dredge spoils from river channels and from building construction and excavation. The behaviour and dispersion of dumped material was studied by sampling of seawater for trace metals, suspended matter and other characteristics following controlled dumps. Particle size distribution spectra were shown to be effective "fingerprints" of the dumped material, which showed a marked increase (by a factor of up to 10) in the relative number of fine particles in the 0.03-4.5 μm range. Relatively high sub-surface metal values for copper, cadmium and lead were also observed after dumping, suggesting release of metals from dumped material.



Sediment collection by the Soutar-Bruland undisturbed box coring device in the Strait of Georgia

To explore the possibility of a chemical screening test for potential dump material, a laboratory study was made on the release of absorption of trace metals (lead, copper, zinc, cadmium and mercury) from a dredge spoil sample, when placed in seawater at a suspended matter concentration similar to natural conditions. Lead and mercury showed a fourfold increase before dropping back to initial concentrations later. A more comprehensive study of the release of mercury from resuspended sediment under different conditions of temperature, salinity and pH in seawater is being conducted to investigate the impact of dredging high mercury sediments.

To reveal the anthropogenic input through dumping the sedimentary record, undisturbed sediment cores were collected off Point Grey, Port Mellon and Vancouver harbour using the Soutar-Bruland undisturbed coring device. Sections of the cores, frozen immediately after collection, were x-rayed for template reference and sub-sampled for trace metal analysis and lead-210 dating. Preliminary results indicated a sharp discontinuity in lead-210 dates when ocean dumping took place. The same technique was also applied to Beaufort Sea samples to assess the sedimentation rates in near-shore areas.

Chemical Oceanography and Pollution Chemistry

(Macdonald, Wong, Bellegay, Jackson, Munro, McLaughlin, Thompson, Paton)

Long-term trends of chemical parameters at Ocean Weather Station "P" (50°N, 145°W) were monitored as a continuing effort of the Division. Newston-net tows were made between Victoria and Station "P" to collect tar balls and other surface pollutants. Samples of total dissolved aromatic hydrocarbons in surface waters were also collected. Weekly samples of atmospheric CO_2, surface alkalinity, total CO_2 and surface radiocarbon were taken. Continuous shipboard infrared measurements of marine air CO_2 and pCO_2 were made on a quarter-yearly basis. Samples of nutrients were taken at Station "P" to provide information about long-term fluctuations in relation to circulation and the marine food chain. The weathership program also included collection of tritium samples and measurements of mercury and dissolved aromatic hydrocarbons in seawater.

On February 19, 1975, four tank cars filled with liquid chlorine were lost from a barge being towed in the vicinity of Malaspina Strait in B.C. coastal waters. Since rupture is inevitable within 2-20 years, Ocean Chemistry Division started an examination of the chemical aspects of the chlorine-seawater system in order to predict the likely sequence of events following tank car failure. A literature search was made to construct the phase diagrams and to predict the likely speciation of chlorine and its effects. In order to fill in gaps in our knowledge, chlorine demand experiments in seawater were performed on seawater collected from Saanich Inlet and on surface sediments from the Strait of Georgia.

On August 20, 1976, some small-scale chlorine release experiments were performed in Saanich Inlet at a series of depths from 25m to 145m using the submersible Pisces IV. The behaviour corresponded quite closely to that predicted on thermodynamic grounds. At 145m chlorine emerged as green liquid drops without observable hydrates. At 90m, green liquid as well as white flakes of hydrates was observed. At 45m, liquid chlorine, hydrates and gaseous chlorine were all seen. At 25m, chlorine came out not as a liquid but as a steady gas plume. No violent explosion was observed and gaseous explosion caused by localized superheating of liquid chlorine is not expected to be a problem at the anticipated water temperature.

The Controlled Ecosystem Pollution Experiment (CEPEX) is an international cooperative program, involving Canadian, American, British, Japanese and West German scientists. It was set up to study the effects of pollutants on mixed trophic levels of pelagic marine organisms, using large enclosures of natural seawater in Saanich Inlet. Ocean Chemistry participation is in its third year with experiments performed on the carbon dioxide cycle, on cadmium and on lead, using a 1/4-scale CEE (Controlled Ecosystem Enclosure) with about 60,000 litres of seawater, and an experiment on low-molecular weight hydrocarbons utilizing the full-scale CEE.

Results from 1975 had shown the insignificance of the removal of cadmium by organic matter and the association of low cadmium content in particulates with high productivity. In 1976, a second cadmium experiment was conducted using two 1/4-scale CEEs, one as control, one spiked with about 1 μg of cadmium per litre. Work is in progress on chemical analysis of samples of dissolved cadmium, particulate cadmium and detritus material.

An experiment on lead was carried out in 1976 using three 1/4-CEEs, with one as a control, one spiked with lead-210 and lead-206, and one with tetraethyl lead. Preliminary results showed that lead decreased by about 50% of its concentration in seawater during the high productivity period of the plankton bloom, and during the levelling off of productivity, the lead levels remained constant. Unusually high productivity occurred in the CEE spiked with tetraethyl lead but the reason is unknown.

During the period of CEE experiments by Dr. R. Lee of Skidway Institute, August 16-30, measurements of low-molecular-weight hydrocarbons were made in a full-scale control CEE at 3, 7 and 19m depths to study the variability of methane, ethylene, ethane and propane with the changing productivity and water conditions in the CEE. All the LMW hydrocarbon

profiles showed the same initial increase at all depths following artificial fertilization. This experiment shows that these hydrocarbons are produced naturally in the ocean - a fact of considerable importance in the interpretation of pollution-related observations.

Dr. J.A.J. Thompson and Mr. D.W. Paton transferred to the Division from the Pacific Environment Institute in July and have been setting up facilities for ocean dumping studies in Howe Sound, on the biotransformation of inorganic mercury into methyl mercury in the sediment. The levels of heavy metals (lead, cadmium, zinc, mercury, copper and chromium) in benthic organisms collected in the dumping areas near Point Grey are also being studied.

Liquid chlorine released from Pisces IV to observe behaviour of liquified gas. Chlorine bubbles can be seen rising and hydrate particles sinking.

OCEAN PHYSICS DIVISION

P.W. Nasmyth - Chief of Division

The Ocean Physics Division has continued to operate through 1976 at approximately the same funding level and with the same allocation of permanent staff as in 1975. Without any significant increase in internal resources it has nevertheless been possible to mount a substantial post-Beaufort Sea program with funds contributed by the Environmental Protection Service and the Department of Indian and Northern Affairs, and the logistic support of industry involved in northern activity.

It has also been possible to increase our level of activity on the British Columbia coast through contracts with the private sector. Over a period of years a substantial capability in the ocean sciences has been developed in local industry, but the extent to which this capability can be utilized is limited, of course, by the availability of funds for contracting. However, with support from the Department of Supply and Services through their 'unsolicited proposal' channel, it has been possible to undertake detailed planning of a major oceanographic contract program to begin in 1977 in the Camano Sound/Kitimat area. The program is in response to increasing demands, predicted in 1974, for information on which to base environmental impact assessments in northern British Columbia coastal waters.

A modestly increased emphasis is being placed on investigations relating to the influence of the oceans on weather and climate. Jointly with the Atmospheric Environment Service, we are continuing to develop techniques and hardware which will, hopefully, lead to an effective Canadian contribution to the 'drifting buoy' component of the First GARP Global Experiment.

The preceding paragraphs touch only briefly on a few highlights and trends. The program of the Division is covered in detail by Section in the following pages.

OFFSHORE OCEANOGRAPHY SECTION

J.F. Garrett - Head

C. de Jong
P. Kimber
L.E. Kuwahara
J. Love
B.G. Minkley
M. Miyake
S. Tabata
R.E. Thomson
W. Wood (summer)

The work of the Offshore Oceanography Section is primarily motivated by the need to establish offshore water-quality baselines, to understand the oceans' role in climate, and to determine the influence of the offshore regime on the coastal regime. In pursuit of answers to these complex oceanic problems, the Ocean Station P monitoring program has been continued and studies of ocean current patterns off the British Columbia coast have been initiated using satellite tracked surface drogues and shipdrift reports. Oceanographic data collected between Station P and the coast is also being analyzed for long period changes in water properties

and for the occurrence of 'events' that could be correlated with short term climatic variations.

Despite its name, work by members of the Section is frequently carried out in coastal water. Usually, but not always, this work is associated with offshore influences. For example in 1976 detailed investigations were begun of currents and water properties within the northern sector of the inside passage between Vancouver Island and the Mainland. These will help provide an understanding of the physical interaction between coastal and deep sea oceanic regions.

Ocean Going Field Research

The oceanographic time series program at Ocean Weather Station P (50°N, 145°W) has been continued into its 21st year with contracts to Seakem Oceanography Ltd. (Victoria) and Chemex Laboratories Ltd. (Vancouver) to carry out observations during the four patrols of the CCGS Vancouver.

In conjunction with the Tidal and Current Section, current meter moorings were maintained at two closely spaced locations in Johnstone Strait. A preliminary investigation of the data supports past evidence of a highly amplified bottom flow at the eastern end of the Strait. During two cruises with the CCS Vector over 250 STD and Hydro casts were obtained between the Strait of Georgia and Queen Charlotte Strait in order to provide detailed sections of the water properties in this poorly studied region of the coast. (Thomson, Huggett)

Two cruises to the Strait of Georgia using the CCS Vector were made to investigate the possibility, suggested by earlier theoretical work, that longshore currents were being generated along the Fraser River Delta by breaking internal waves. The records from three current meter moorings in this region will also assist in our understanding of sediment and pollution dispersal by currents off the mouth of the Fraser River. (Thomson, Huggett)

Data Analysis and Theoretical Research

Satellite imagery of the western Arctic Ocean has been used to demonstrate that the large scale (100 km) criss-cross lead patterns in the ice cover are analogous to semi-brittle fracture patterns found in rock mechanics. This concept marks an appreciable departure from present theories about lead formation in the Arctic ice cover. (Thomson, Marko)

The Vorticity Transfer Theory proposed by G.I. Taylor early in this century has been shown to be fundamentally incorrect. This result establishes certain limitations on theories of ocean circulation. (Thomson, Stewart)

Analysis of surface current velocity data for the North Pacific obtained from U.S. and Japanese pilot charts has revealed the presence of a westward flowing countercurrent between 48°-51°N latitude. Although the current appears to be especially strong during winter months, attaining speeds of 10 cm/s in a confined latitudinal belt 100 kilometers wide, it appears that its presence has not previously been remarked upon. (Tabata)

Ten years of time-series data from meteorological and bathythermograph observations at Ocean Station P have been analyzed in order to determine values for various transfer coefficients at the air-sea boundary. In some cases, appreciable variation from accepted values has been found. These coefficients are essential parameters in the modelling - both of the ocean and of the atmosphere. (Miyake)

The paths of five locally built drifting buoys, launched near Station P, were tracked by the Nimbus-6 satellite in early 1976. All buoys were carried toward the coast. Those that retained their drogues also moved with large north-south excursions that had periods of around two weeks with speeds of two to six miles per day. (Garrett)

An assessment has been made of the usefulness of satellite imagery in the study of Oceanography along the Pacific Coast. Particular attention has been given to the use of infrared imagery to detect cold upwelling regions adjacent to the coast. (Tabata, Gower)

The quality of oceanographic data collected during the Weather Ship program is presently being assessed. Results of this study will be important to international use of this data and for determining procedures for up-grading its quality.

Support Programs

As part of Canada's contribution to the First GARP Global Experiment (FGGE) in the southern Pacific in 1979, supportive research was directed toward the design of instrumentation for the measurement of barometric pressure and sea surface temperatures from drifting buoys. Under contract, Beak Consultants Ltd. (Vancouver) completed a feasibility study of deploying drifting buoys from volunteer ships. Tests were conducted by the Section on the possible use of commercial pressure transducers in the buoys. The stability and accuracy of these sensors appears to be adequate for long term operations in the Southern Hemisphere experiment. (Garrett)

Hermes Electronics (Halifax), as part of the Canadian Ocean Data System contract, constructed 25 prototype drifting buoys for testing in the Southern Hemisphere with the Nimbus-6 satellite in early 1977. The small size and advanced design of these buoys permit them to be easily deployed from ships and make them highly suitable for the FGGE. (Garrett)

A comparison of the accuracy of Expendable Bathythermographs (XBT's) and the temperature records from STD's has shown that the two instruments have a mean difference of 0.01°C and a standard deviation of 0.10°C. Much of this difference was attributed to variations in the fall speeds of the XBT probes. (Garrett)

An onboard data-logging system developed by the Section in 1976 for rapid collection and dissemination of STD data has proved extremely useful in field operations. Our ability and efficiency in getting such information into directly useful form has also been appreciably enhanced.

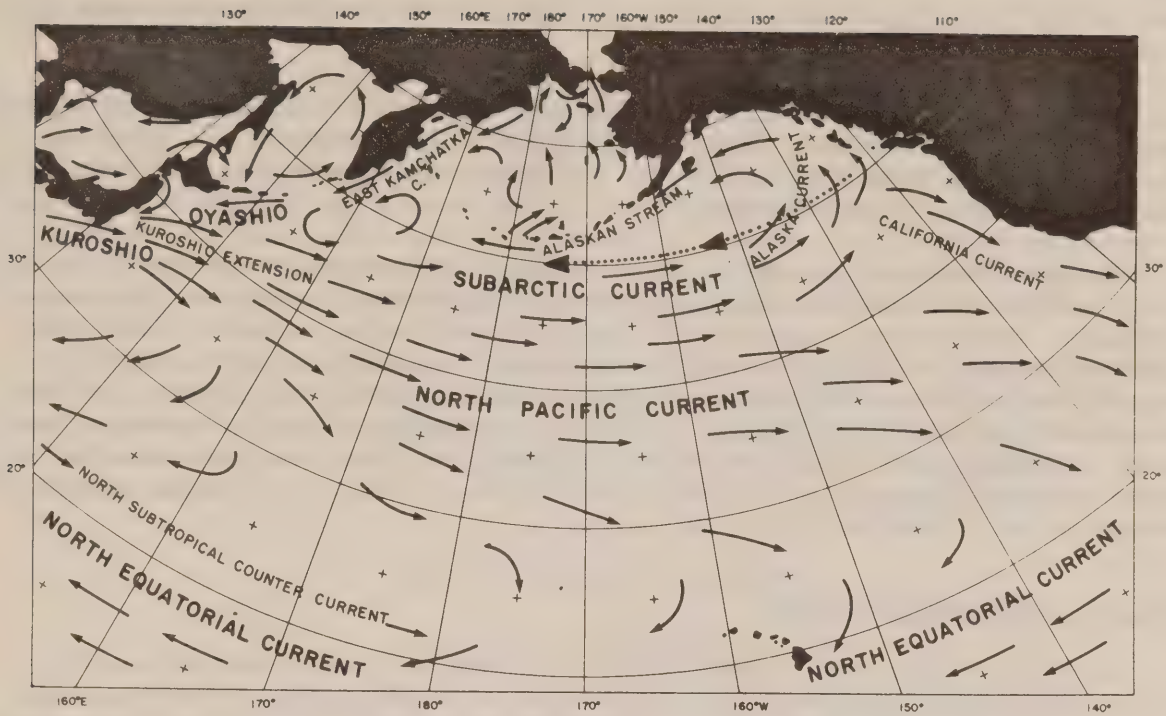


Chart showing the distribution of major surface currents of the North Pacific Ocean. The dotted line indicates the location of the recently postulated countercurrent.

COASTAL ZONE OCEANOGRAPHY SECTION

D.M. Farmer - Head

W.H. Bell	J.H. Meikle
R.H. Bigham	D.G. Sieberg
L.F. Giovando	L.A. Spearing
G. Kamitakahara	J.A. Stickland
A.P. Lee	D.J. Stucchi

Field Studies

In cooperation with the Tidal and Current Section, the Section undertook a current-meter observation program in Haro Strait in July and August. The intention was to examine some of the gross characteristics of the mixing and exchange processes occurring in the strait and to establish space and time scales of the major fluctuations. Instruments were moored at eight locations in a line across the channel. Despite a number of technical problems, including large vertical excursions of subsurface moorings induced by cable drag in the rapid currents, it appears that a good data set was obtained. The current-meter program was supported with CTD profiling, thermistor chain measurements and remote sensing observations. Preliminary data analysis has disclosed large changes in (tidally averaged) salinity and temperature structure between spring and neap tides as well as more rapid fluctuations occuring within each tidal cycle. Fronts travelling

through the strait produced visible surface effects which were recorded by camera from San Juan Island.

A monthly sequence of CTD observations was undertaken in Saanich Inlet, Satellite Channel and Haro Strait to provide background data for our continuing study of deep water exchange in Saanich Inlet and our study of exchange processes in Haro Strait.

As part of a program designed to examine the mechanisms involved in fjord circulation the Section conducted a pilot study in Knight Inlet in November. Time series temperature, salinity and current observations from a moored vessel, taken to determine potential sampling problems, have revealed the presence of a large amplitude surge possibly generated by interaction of the tide with the sill. A rapid deepening of the fresher surface layer accompanied by large amplitude internal waves of about ten minute period occurred about three hours into the flood tide at our anchor station located a few kilometers up-inlet of the sill.

Analysis and Interpretation

Analysis of the large body of data obtained in Rupert and Holberg Inlets in 1975 has continued, with the emphasis on elucidating the principal mechanisms for deep water exchange. Observations taken by recording instruments in Quatsino Narrows suggest a sensitive relationship between salinity in the Narrows and the form of exchange that takes place. Magnetic particles from mine tailings in the water interfered with observations of both current speed and conductivity, causing major difficulties in data analysis. Some additional current measurements were taken in Rupert Inlet in support of a study of mine-tailings movement by the Institute of Oceanography, U.B.C.

Studies of ocean dumping in coastal waters were undertaken, mainly by contract. These included a review of existing dumping technology, mathematical models for dispersion of dumped material, and a survey of oceanographic data in B.C. dumping sites. Dumping activities in Alberni Inlet motivated a study of deep water exchange based on historical data from that region. A watching brief was maintained on contemporary developments in dumping technology.

The program of salinity and temperature observations from B.C. lighthouses has been continued. A review of some of the historical lighthouse time series has been undertaken and a study initiated to examine critically the present program in the light of the varied needs of data users.

A submission on the physical oceanography of B.C. coastal waters was prepared for the Coastal Zone Resource Committee and two reports prepared summarizing results of studies conducted under the auspices of the Beaufort Sea Project.

Analysis of data collected during the Babine Lake project continued, with emphasis on mechanisms involved in the generation of internal surges.

Technical Development

Investigation of some practical mooring problems associated with drag due to fast currents was carried out by numerical simulation. In addition, trial moorings were undertaken in an area of swift currents in order to provide data for comparison with the model and to check out alternative procedures. Problems were encountered in one test mooring due to instability of cylindrical buoys, as well as instrument failure, and further tests are required. But a trial mooring of a new cable fairing indicated a useful improvement in performance despite some handling problems.

Effort was spent in developing our CTD profiling capability so as to permit (1) preliminary data processing facility by mini-computer during field operations and (2) portability of the system to allow its use on a variety of vessels. Work was begun on the development of a profiling current meter.

ARCTIC MARINE SCIENCE

A.R. Milne - Head

R.H. Herlinveaux B.D. Smiley

The main thrust of the Arctic Marine Science program has been devoted to environmental investigations related to offshore petroleum development. These studies had two major subdivisions, one being on threats to the environment likely to be caused by offshore petroleum development, and the other to threats from the environment to offshore drilling systems. To a lesser extent we were engaged in baseline studies, which are studies of the current state of the Arctic environment. It is anticipated that in the future most work will be related to environmental assessment. As such, it is likely that we will be engaged in joint programs with other agencies, either in the context of spearheading the programs themselves, or conducting joint programs of mutual interest.

The majority of the funds (approximately 80%) obtained during the fiscal year 1976-77 were expended on contracts. It is anticipated that 80% of new funds allotted to Arctic Marine Science would again be expended on contracts.

The Beaufort Sea Project was an arctic marine environmental assessment program financed jointly by the Federal Government and 18 member companies of the Arctic Petroleum Operators Association. The management of the entire project, including editing of all reports, was the responsibility of the Arctic Marine Science Group. While field studies ended in September 1975, there remain seven technical reports outstanding of a total 46 technical reports expected. Six overview reports, designed for the interested layman, are in various editorial stages. So far, about 15,000 copies of technical reports have been distributed.

During 1976 field and laboratory studies focussed on the Canadian Arctic Archipelago and to a lesser extent on the Beaufort Sea. These studies were mainly marine environmental research related to petroleum

development and possible oil spills and their effects.

The main arctic study in 1976, funded by the Department of Indian and Northern Affairs, related to the possibility of oil spills from tankers, marine pipelines or underwater oilwell blowouts in the vicinity of recent oil strikes on Cameron Island by Panarctic Oils Ltd. Ice movements in Byam and Austin Channels were tracked using radar during August and September; concurrent satellite imagery and surface wind measurements provide supplemental information on general ice drifts in the region. The radar showed a consistent eastward ice drift across the north end of Byam Martin Island.

The porosity of sea-ice, which influences the rate at which an oil spill under the ice would rise to the surface, was measured at three locations in the Arctic Archipelago between July and September 1976. The picture was taken in Barrow Strait in September.

The porosity of multi-year sea ice was investigated from early to late summer in a study designed to throw some light on the permeability of old sea ice to oil trapped beneath it. Three sets of data, obtained under surface layer increased with thawing and the ice in contact with the sea also became more porous as the ice warmed to sea temperature at the end of summer. This study was funded by the Environmental Protection Service of the Department of Fisheries and the Environment.

In October, an environmental review of the proposed marine drilling by Norlands Petroleum Ltd. in Lancaster Sound was initiated with funding support by DINA. The review is to be completed by August 1977 and will consider the possible impact of a deep-water oilwell blowout on the biota of Lancaster Sound.

In connection with the environmental review and the study carried out in Byam and Austin Channels, two complementary studies are underway. The first consists of a review of field data from the Arctic Archipelago using all available sources. The aim is to understand the surface, subsurface and ice movements in the channels of the Archipelago by tracing water masses and wherever possible inferring geostrophic currents. The second study is of ice movement patterns as they relate to oil-spill trajectories, primarily in the Sverdrup Islands and Parry Channel. Landsat and NOAA satellite imagery provides sequential observations of ice floes and ice edges.

In the Beaufort Sea, wave-rider buoys were deployed in a cooperative wave study with Imperial Oil, Canadian Marine Drilling Ltd. and DFE's Marine Environmental Data Services. Locations of buoys were off Kugmallit Bay, Pullen Island, Garry Island, Warren Point and from a CanMar drillship.

In winter, from November 1975 to late March 1976, an ice-camp was occupied in the shear zone of the southern Beaufort Sea from which oceanographic, meteorological and ice movement observations were carried out. Ice reconnaissance using aircraft extended to July 1976. The work was carried under our supervision by Norcor Engineering and Research Ltd. of Yellowknife.

The Polar Continental Shelf Project provided extensive logistic support during the 1976 field season.

FROZEN SEA RESEARCH GROUP

E.L. Lewis - Head

J.W. Butcher - Computing Services
R.A. Cooke - Survey Electronics
A.W. Koppel
R.A. Lake
+J.M. McNeill
A.E. Moody
S.W. Moorhouse
*P.E. Oswald
R.G. Perkin
D.L. Richards
+E.E. Richards
R.B. Sudar
D.R. Topham
E.R. Walker
+P.E. Greisman - Post-doctoral Fellow

+Joined in 1976
*Left in 1976

The Frozen Sea Research Group was established in 1964 to study oceanographic problems unique to ice covered waters and their research efforts have been concentrated in the Canadian Arctic. Much of their expertize in the scientific understanding of oceanographic processes in Arctic waters is now being directly applied to the problems associated with the exploration and exploitation of petroleum resources in the far north. The projects undertaken in 1976 are summarized below.

Water Movement in Channels of the Arctic Archipelago

Current meters were laid across Byam and Austin Channels between Melville and Bathurst Islands at a latitude of about 75°N. The meters were placed in the top and bottom boundary layers with a view of obtaining information on the potential for the movement of oil beneath the sea ice and the forces likely to act on a pipeline crossing planned at that location. Density profiles were also obtained. The movement of pollutants from a hypothetical oil well blowout in the Arctic Islands is at present largely unknown and studies of this type are an essential part of predicting the environmental consequences of such an event.

An overall survey of the oceanography of the Arctic Islands has been undertaken to provide a background for industrial developments. An attempt is being made to model one aspect of the Archipelago based upon a review of meteorological data, water structure variability, long term water level variations, and the magnitude of water level runoff from the land.

Circulation in Arctic Fjords

These continuing studies have been centred at Cambridge Bay, Victoria Island and d'Iberville Fjord, Ellesmere Island, with the 1976 field trip being to d'Iberville Fjord. The operation culminated in an oceanographic section running 200 kilometers approximately from the glacier at the head of d'Iberville Fjord out over the sill, down Greely Fjord into Eureka Sound and so to Eureka itself. These studies of circulation are essential to understand and predict the extent of pollution possible from depositing mine tailings into the ocean at these latitudes. During 1976 advice was provided in connection with Nanisivik Mines, Strathcona Sound, and the proposed Arvik Mine on Little Cornwallis Island.

As the ice cover prevents wind mixing, and run off from the land is restricted to a few months of every year, Arctic Fjords are a simpler circulatory system than fjords at more temperate latitudes. Results from studies on Arctic fjords may thus be used to elucidate problems arising due to coastal pollution in southern Canada, for example, on the British Columbia coast.

As the sea ice grows salt is rejected into the underlying water column producing vertical convective motion immediately below the growing interface. The dynamics of this process are of great interest in regard to the lodgement and dispersal of oil deposited at the ice/water interface by an offshore oil well blowout as well as in terms of the fundamental physics of the atmosphere/ocean energy exchange and its effect on world climate. Studies on this convective system were continued during 1976 and will carry on into the next fiscal year. Although the process is being studied in fjords it is of importance under any sea ice cover.

Direct Environmental Effects of an Offshore Oil Well Blowout

Studies have been pursued on changes of the ice surface albedo due to contamination by crude oil, the atmospheric pollution to be anticipated from burn-off of a blowout, and the rupture of a sea ice sheet due to the accumulation of gas at the ice/water interface. Gas (methane) invariably accompanies an oil flow and if retained in the relief at the ice/water interface in sufficient quantity, will eventually cause the sheet to crack thus providing a path for oil to reach the upper surface. An analysis of this problem has been accepted for publication in the open literature. A detailed analysis of the results obtained from the simulated blowout carried out in Patricia Bay during 1975 using compressed air is now available and supplements the preliminary study given in Beaufort Sea Report #33.

Instrumentation

As a result of the need to plan the recovery of the bottom current meters from beneath the sea ice, a study has been made of mooring systems to predict the depression and horizontal movement suffered by our subsurface floats marking the current meter locations when they are dragged by local currents acting on the mooring line. It was found that the commonly used equations did not express the drag components on the line properly and a new expression has been derived that introduces a small, but often significant, correction to the cable profile as previously predicted.

We have extended our experiments into the stability and reliability of the CMI ultrasonic current meters preparatory to an attempt to measure correlation coefficients in the turbulent structure of waters convecting be-

neath growing sea ice. As a necessary adjunct, the interfacing of this equipment to a small computer has been studied for an interactive experiment allowing immediate adjustment to parameters in terms of observations made. Numerous minor modifications to our arctic current meter system have been made to improve reliability as a result of this year's experience.

Considerable effort has been expended to build a sensor chain which, through simultaneous measurement of temperature and conductivity, will yield salinity. Experiments so far have been confined to the laboratory but are encouraging, and the first field tests are anticipated early in 1977.

Telemetering equipment installed in the sea ice for data relay to a remote recording station. The central vertical black tube forms a float, extending through the ice sheet, which contains the radio transmitter as well as internal recording gear for under ice water movement. A hydrophone hanging beneath the float receives sonic pulses which are coded data on water movement near the sea bed and information on both top and bottom currents goes to a recorder on land via the UHF antenna on the left of the picture.

Definition of Salinity

A study has been made of the definition of salinity and its calculation from conductivity measurements. The problem is complex and has arisen because the precision and accuracy of modern measurement resolves changes in the conductivity-salinity-density relationship met with as the result of variations in the ionic composition of seawater or different authors' data reduction formulae. Very significant errors can occur in a comparison of data from one cruise to that from another made by a different institute using different instruments and different equations. Presently, internationally accepted definitions and relationships do not extend to the temperature range of greatest importance for in situ readings and do not allow the easy comparison of a local water mass, with its particular chemical composition, to that used in providing the definition. A study of the problem and a recommendation on a new definition of salinity has been published.

OCEAN MIXING SECTION

P.W. Nasmyth - Head

A.E. Gargett
G.W. Chase
R.C. Teichrob

For over 20 years a modest program has been in progress on the West Coast of Canada to investigate the characteristics, occurrence and distribution and intensity, of turbulence and other small scale mixing processes in the ocean. Sensors and measuring equipment and techniques of data analysis have been developed, some of which are unique in the world.

The mixing processes determine to a large degree the vertical transport of heat or energy and of dissolved or suspended materials through the ocean. The rate at which heat is transported to or away from the surface layer is of major importance in understanding the exchange of energy between the ocean and atmosphere and its effect on weather and climate. Improved knowledge of the air-sea exchange will contribute to improved effectiveness and range of weather forecasting. Knowledge of the mixing processes will also contribute to an understanding of the transport and dispersion of both pollutants and nutrients in the sea. Indeed it is generally agreed that improved understanding of mixing is essential to the construction of reliable three dimensional predictive models of the deep ocean or of coastal waters.

The project now being carried out by the Institute of Ocean Sciences was originally undertaken and developed by the Department of National Defence. In earlier stages, sensors were towed from a surface ship. When the deep submersible Pisces IV was acquired by the Department of Fisheries and the Environment in 1974, the development of new instrumentation was undertaken to make measurements from Pisces, with greater flexibility of operation and greater depth capability than the towed system.

Measurement System Development and Use

In 1976 the new system has been carried through to the point where successful performance has been achieved. In order to get a stable 'flight path' it was necessary to design a set of stabilizing fins. Extensive experience in over 50 dives with the fins installed has proved completely satisfactory.

An interim system of sensors and a data recording package have been developed, installed and tested in Pisces IV for measurement of:

i) three components of fluctuating turbulent velocities with a spatial resolution of 0.5 cm in the longitudinal component and 3-5 cm in the cross components,
ii) temperature with a spatial resolution of a few millimeters,
iii) conductivity with a spatial resolution of a few centimeters.

Auxilliary instrumentation measures depth, mean forward motion, vibration and submarine motions in pitch and roll, and mean water velocity past the sensor array.

Two sea operations, totalling approximately 45 days at sea, were

carried out during the year, primarily to test the performance of components of the system in various modes of operation. Most recently a 5-week series of trials of the total system was carried out in November/December 1976 in four parts:

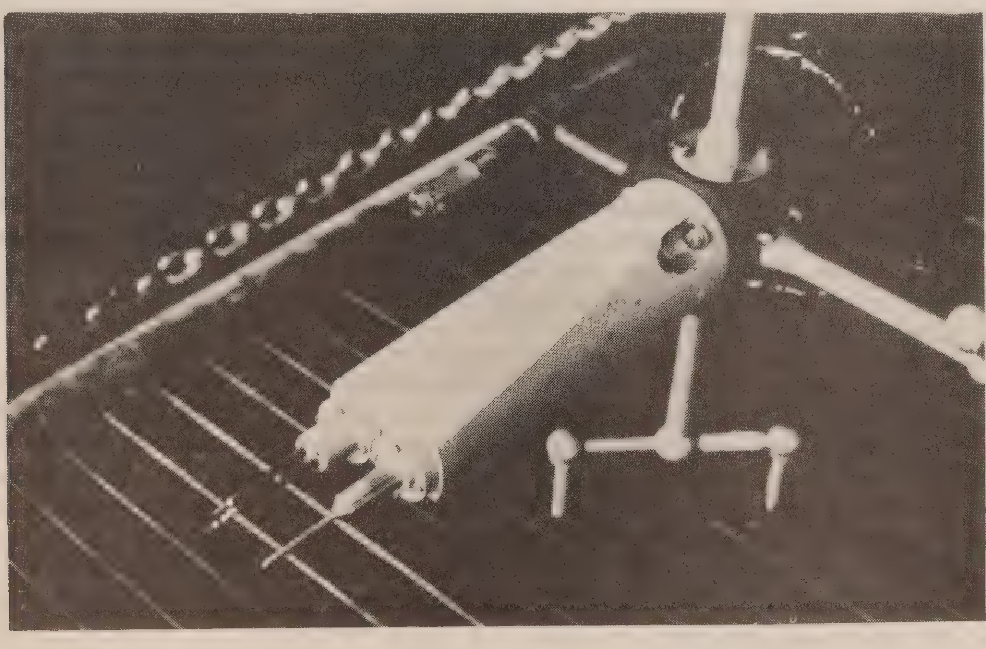
i) in the deep quiet waters of Bute Inlet to establish noise levels for all components of the system,

ii) in an area of strong turbulence south of Cape Mudge which has been extensively studied with earlier ship-towed equipment, to compare system performance with previous results,

iii) in the area of the Fraser River plume to investigate the boundary layer between the river water on the surface and Strait of Georgia water beneath, and

iv) 1-5 metres above the bottom in Malaspina Strait to investigate the feasibility of operating in the bottom boundary layer.

While these trials were of an exploratory nature to define the capabilities of the system and develop operating procedures, a considerable amount of good data was obtained and analysis will proceed during 1977.



The main grouping of sensors mounted on a special framework in front of the submersible Pisces IV for measurement of ocean turbulence and microstructure. Three high resolution probes mounted at the extreme forward end of the structure appear at lower left in the picture. The two close together at the left use very small platinum films to measure water temperature and the longitudinal component of velocity. The third uses a piezoelectric element to measure the two cross components of velocity. The sensor in the upper centre measures electrical conductivity and temperature, from which density is calculated. An acoustic current meter (bottom right) and two others to the right and on top, of which only the mounting stems can be seen, measure three orthogonal components of mean water velocity past the sensor array.

Analysis of Data

A data analysis scheme was devised and tested in 1976 for obtaining information on the vertical gradients of temperature and salinity from a purely horizontal measurement, taking advantage of the fact that internal waves continually raise and lower constant density surfaces in the ocean. A temperature versus salinity (T/S) plot of the time series of horizontal data indicates whether the local temperature and salinity gradients have the same or opposite signs. Addition of the sign of the difference between two temperature measurements spaced 1 m in the vertical then completes the deterinination of the signs of the gradients. A measure of the strength of the local density gradient may be obtained from the slope of the curve in the T/S plane. Such information will be essential to proper understanding of high frequency velocity and temperature measurements which were taken at the same time during towed body operations in 1973. Analysis is continuing, but this work has already demonstrated that 'double diffusion' phenomena, depending on the difference in diffusion rates between heat and salt, may be important even in the North Pacific. Conventional wisdom, based on less detailed observations, has been of the opposite opinion.

A complete set of programs was put together for the analysis of data obtained with CAMEL, a profiling microstructure instrument belonging to Dr. T. Osborn of IOUBC, during a joint microstructure experiment with Woods Hole Oceanographic Institution in the fall of 1975. Processed data for each of 26 profiles include digital chart records, with signals displayed as functions of pressure rather than time, estimates of the rates of dissipation of turbulent energy calculated from the output of the Osborn shear probe, as a function of pressure, and plots of temperature and temperature difference on scales agreed upon for intercomparison. Completion of this processing within a year has been a major effort. The data will be analysed during the coming year.

Another important project has been the development of display programming for use during operations with Pisces IV. It is necessary to check signals during the first part of any operation, when instruments are being mounted and debugged. It is also desirable to be able to display signals in scientific units and with changeable gains during any operation, both as a continuing check that instruments are operating properly and as an aid to planning further investigation. To these ends, we have developed very flexible display programs, allowing choice between volts or physical units, and choice of gain and off-set.

REMOTE SENSING SECTION

J.F.R. Gower - Head

J.S. Wallace
R.A. Neville - NRC Postdoctoral Fellow
B. Oliver - NRC Postdoctoral Fellow

In 1971 the Remote Sensing Section was established in the Pacific Region to take Marine Sciences' (now Ocean and Aquatic Sciences) responsibility for development of remote sensing techniques for oceanography and for evaluation of techniques originating elsewhere.

Imagery from satellites has become a powerful tool for observation of ice characteristics distribution and motion in the Arctic and gives promise of becoming comparably useful for determination of sea-surface temperature, surface currents and wave height, synoptically over large areas of ocean. Photography, infrared imagery and spectrometric examination of sea-surface radiation from aircraft also offer large area coverage which would be impossible to duplicate by measurement from the surface and prohibitively expensive. Certain other techniques such as photographic time series taken by a camera suspended by balloon, and precise optical tracking of drifting targets on the sea surface using an aircraft equipped with a modified inertial navigation system have also been exploited by the Section.

The Remote Sensing Section has no operational program of its own; it develops techniques and assists other sections or agencies. During 1976 the Section was involved in satellite oceanography (infrared sea-surface temperature and radar wave height measurements), airborne observations of coastal B.C. waters using the Marine Inertial Data Acquisition System (MIDAS), a detailed water-color analysis using the 256 channel spectrometer, and imagery and photography in support of various programs.

Satellite Oceanography

The usefulness of infrared sea surface temperature patterns has been demonstrated in many parts of the world as well as by our own analysis of NOAA VHRR data for the B.C. coastal waters. We have encouraged the construction of a permanent west coast satellite receiving station in Vancouver and are developing a minicomputer image enhancement facility to process the data to our requirements.

GEOS-3 radar altimeter data continued to arrive during the year, but in small volume and with numerous complications that are hampering U.S. and Canadian analysis projects. It appears that wave-heights should be measurable to within 0.5 metres along the satellite track, and future satellite systems, such as SEASAT, should considerably improve reporting of ocean wave conditions and could also be used in weather forecasting. Since sea surface elevation is also measured, a project to analyse ocean tide heights is also planned.

Planning for the prototype SEASAT A project continues with J.R.F.Gower on the NASA team for the synthetic aperature radar experiment and on the Canadian Committee for SEASAT A participation.

Airborne Oceanography

The MIDAS system has now been developed to the stage where aircraft track recovery is accurate to better than 10 metres at all times and the positions of targets and ocean features sighted by the operator can be measured to the same accuracy. The system has been used to map surface currents in Haro Strait using floating targets deployed by launches. Interactions of water bodies at tide lines can be followed by recording both tide line and target positions. The system has also been used in an ocean dumping exercise off Point Grey and to follow the development of the Fraser River plume. Instruments have now been added to record the wind velocity at the aircraft's flying height. This is to be used to support tests of drift models for oil spills in Juan de Fuca Strait.

An examination of the effects of different vertical distributions of

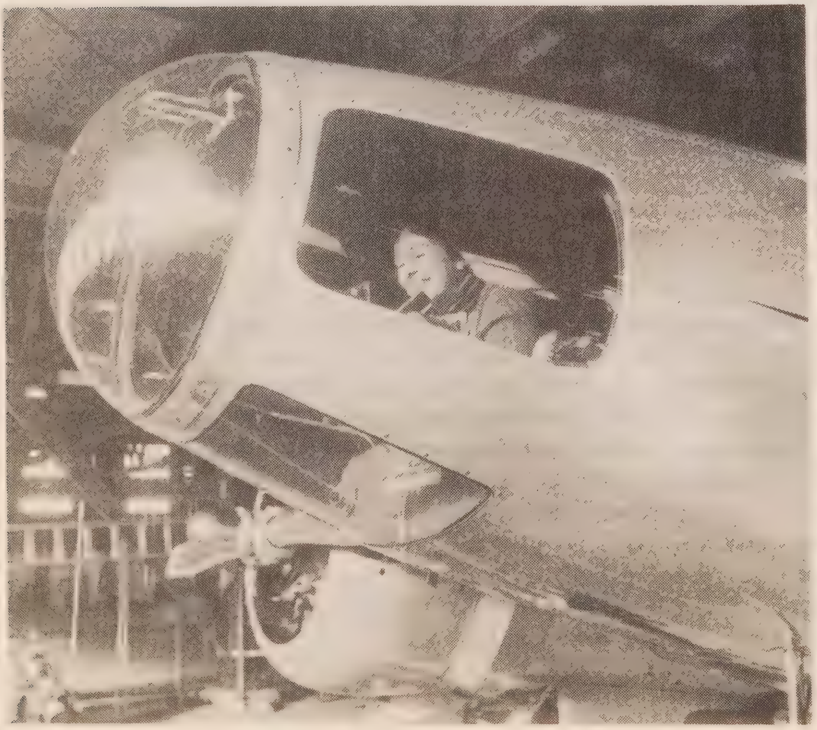
chlorophyll on water color and fluorescence line height was carried out in Saanich Inlet using the 256 channel spectrometer. Previous measurements here and elsewhere show that chlorophyll concentrations can be estimated and mapped from the air, but that data tends to show only concentrations near the surface. Since layers of high chlorophyll concentration are often present at various depths, the resulting maps can be misleading. Preliminary analysis shows that it should be possible to deduce information of the vertical distribution of chlorophyll from an aircraft using both color and fluorescence data from the spectroscopy.

The spectrometer was also used in Ottawa for water color measurements by the Canada Centre for Remote Sensing and for measurements of soil spectra by the Geological Survey of Canada.

Three thermal scanning flights over Haro Strait were made by Intera Environmental Consultants Ltd. (Vancouver) using a Cessna 206 aircraft flying at an altitude of 16,000 feet. The imagery showed fronts between water bodies of different temperatures, with evidence of upwelling, and of surface stratification as revealed by ship wakes. Such imagery can be recorded day or night, but cloud free conditions are required.

Oblique photography in Haro Strait was taken by an unattended super-8 time lapse camera attached to a tree near the top of Mt.Dallas on San Juan Island. Fronts associated with the incoming tide pass close to the foot of the mountain and could be seen on the film on 57 days out of 73. Front velocities could be deduced on 24 occasions and timing was accurate to about ten minutes.

The last two projects were done for the Coastal Zone Oceanography Section of the Institute.



Beach 18 aircraft belonging to B.C. Government is used by Remote Sensing Section for tracking surface targets in support of oceanographic programs measuring surface currents and tracking oil spills. It is also used for developing and testing instruments for measuring water color.

NUMERICAL MODELLING SECTION

R.W. Stewart - Head

P.B. Crean
P.J. Richards - Computing Services
R.F. Henry
M.G. Foreman - Computing Services

The Section is involved in the development and application of numerical models for simulation of currents and surface levels in areas of high priority study. Numerical models form a species of theory, and share with other kinds of theory two characteristics: (1) The better the theory, the fewer the observations required to describe any situation. Properly employed, theory can be cost-effective for this reason alone. (2) Theory permits prediction. For example a successful model, once developed, may then be run on the computer under any desired set of conditions to determine currents and levels over the area for any period of time, - information which could be obtained only with great difficulty and expense by other means. An appropriate model may also be used to predict the movement of, for example, an oil spill under any combination of wind and tide.

Georgia Strait Modelling

A sophisticated two-dimensional tidal model of the Strait of Georgia/ Strait of Juan de Fuca system, considered to be one of the most successful of its kind in the world, has been under development for several years and is still being refined. During 1976 an extended run (30 days) was carried out on the Strait of Georgia model, simulating measured and predicted values with gratifying precision. Analysis of the resulting data shows the existence of significant non-linear interactions between the dominant tidal constituents. These interactions are primarily due to frictional dissipation in the region of the San Juan Islands. Earlier versions of the model of more limited regional extent, though consistent with general practice, were too dynamically insensitive to permit the degree of adjustment required to reproduce the interactions.

Data from this model are being used to drive a finer scale model (2 km mesh size) for more detailed coverage of Juan de Fuca Strait, the southern Strait of Georgia and the region of the San Juan and Gulf Islands. This is the region of most concern with respect to tanker traffic in southern coastal areas.

An exploratory 'upper layer' model is being developed to simulate the Fraser River plume. Extensive field observations are being obtained to assist in the design and operation of this model. It is proposed that data from the fine grid model, referred to above, will provide the effects of the tides and streams in the Strait of Georgia on the motions of the plume. This is a collaborative study with Dr. P. LeBlond and Mr. J. Stronach of the Institute of Oceanography, University of British Columbia. No realistic pollution or ecological model of this area will be possible until the Fraser plume is incorporated. (Crean)

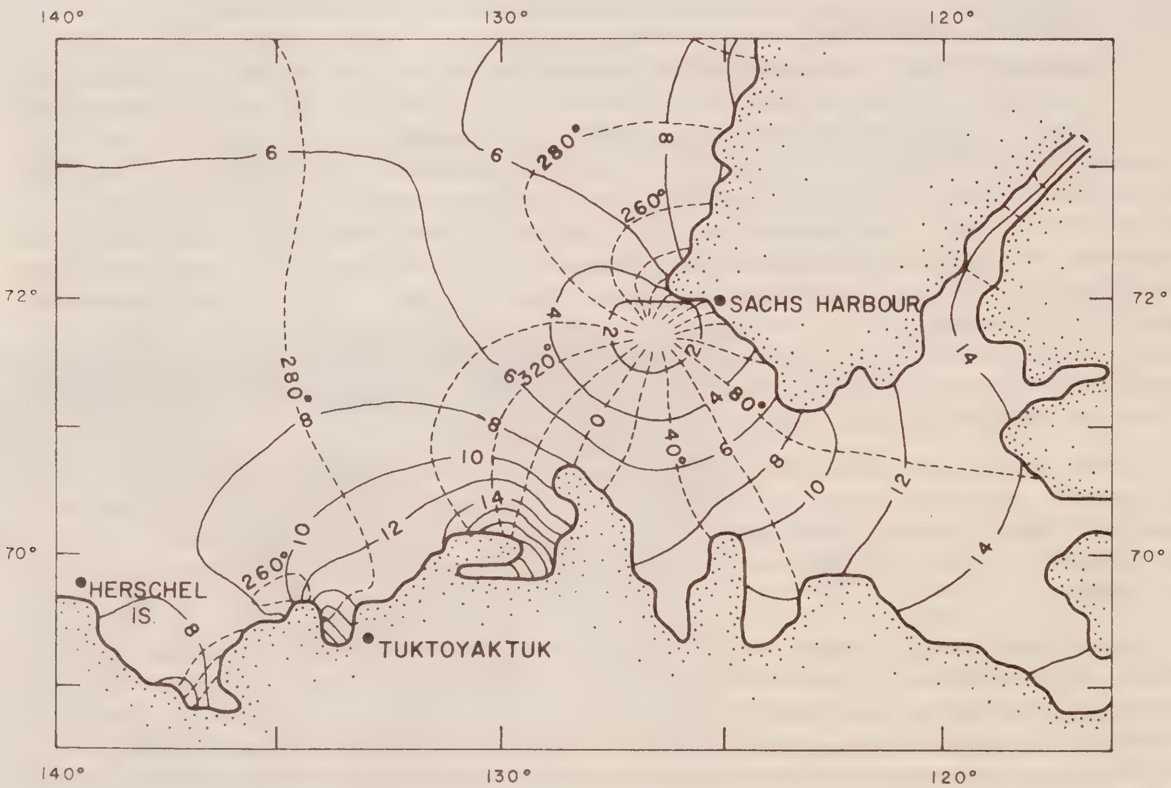
Simulation of Tides and Storm Surges

Tidal and storm surge models of the southern Beaufort Sea and Amundsen

Gulf have been developed as part of the Beaufort Sea Project. These models have served to confirm that wind stress on open water is the dominant cause of surges and that the shallow coastal shelf is the area where surges are generated. Outflow from the Mackenzie River has been shown to increase surge heights in the southern part of Mackenzie Bay. A small area surge model is designed for incorporation into an operational air and sea forecasting system to be run by the Atmospheric Environment Service in support of drilling operations in the Beaufort Sea, and of clean-up operations in the event of an oil spill.

A barotropic model has been developed for simulation of semidiurnal tides in the Beaufort Sea and Amundsen Gulf. Until now cotidal charts have been based on observations only, and were confined to the Mackenzie Bay - Cape Bathurst shelf area. The model results permit provisional extension of charts for the semi-diurnal constituents of Amundsen Gulf and the waters off Banks Island.

Preliminary study and data preparation has been undertaken towards the development of a barotropic tidal model of Queen Charlotte Sound, in anticipation of increasing demand for environmental impact studies in the Prince Rupert - Kitimat area. (Henry)



Cotidal chart for lunar semi-diurnal (M_2) tide in the southern Beaufort Sea, based on a simulation by means of a numerical model. The chart agrees satisfactorily with field observations where available. Full lines are amplitude contours of surface elevation (cm). Co-phase lines are shown dashed; the tide reaches the same state (eg. high tide) simultaneously at all locations on a given co-phase line.

OCEAN ECOLOGY LABORATORY

R.O. Brinkhurst - Head

M.J. Austin
G. Gardner - Postdoctoral Fellow
P. Chapman - Graduate student, UVic
W. Carolsfeld - Summer student

In the course of discussions during 1974 and 1975 on the organization of the Fisheries and Marine Service, it became clear that a gap in programs had developed over the years. The study of non-commercial organisms, even those used as food for commercial fish and those which were important indicators of the health of the ecology, was being seriously neglected. It was agreed that the effort in this area would be increased and that the work should be carried out by OAS rather than by Fisheries Management.

These decisions were closely in line with proposals made in 1971 for the range of expertise which should be incorporated in the proposed Institute of Ocean Sciences. Accordingly, the nucleus of an Ocean Ecology Laboratory was established within the Institute early in 1976.

The mandate of the laboratory is to carry out bio-oceanographic studies in support of the Departmental and Institute objectives, and especially to act as a catalyst between the governmental and academic biological constituency and the physical and chemical scientists of the Institute. The Laboratory Head transferred from the Atlantic Region of Fisheries and Marine Service in January 1976, so this year has been one of policy discussion and acquisition of base-line equipment, library needs and such mundane issues as a place to work pending the completion of the new Institute of Ocean Sciences facility.

An obvious need in the Region is for a time-series of oceanographic and biological information along the Canadian shelf to provide background for studies of ocean climate, environmental disturbances such as a build-up of hydrocarbons or CO_2 level changes in the atmosphere, and for fisheries managers seeking anomalies that can be related to survival of young fish at sea. The combination of severe weather and lack of adequate platforms has made the shelf difficult of access, and this remains the major problem. A ship-of-opportunity program is being investigated as a feasible method by which the large amount of data needed for a time-series may be collected in a cost-effective way.

While the planning for plankton studies in continental shelf and inshore waters continues, benthic (bottom) studies are underway. Contracts have been let for studies on the effect of dredge spoil rich in wood wastes in Alberni Inlet, for the identification of other collections of benthic samples, and for a first look at the benthos of Saanich Inlet. These are part of a long-term aim to examine the oxygen budget of inlets and the value of benthic associations as indicators of natural and man-made stresses. This bio-indicator concept has proved itself in the well-established area of fresh water sludge-worm biology.

During the year, Carolsfeld studied the fauna of the major urban drainage system reaching Victoria Harbour, and Chapman and Carolsfeld used Westwater Institute samples of oligochaeta from the lower Fraser River to examine distribution in relation to pollution and the salt wedge. The laboratory continues to advise biologists on the taxonomy of sludge worms, and a significant collection from Tasmania has proved especially interesting.

OCEAN ENGINEERING DIVISION

W.N. English - Chief of Division

COMPUTING SERVICES SECTION

K. Teng - Head

R.E. Johns
D.B. Smith
J.W. Butcher - FSRG
A.N. Douglas - Tidal & Current
R. Dykes - Management Services
M.G. Foreman - Numerical Modelling
*R.G. Hlady - Management Services
J.S. Page - Ocean Chemistry
P.J. Richards - Numerical Modelling
E. Wong - Offshore Oceanography
A.L. Woollard - Tidal & Current

*Left during 1976

Departmental Computer

1976 saw the establishment of a large Regional Computing Centre for the Department in the Institute facilities at Patricia Bay. The Univac 1106, purchased from Bell Northern Research, will serve the needs of the Institute of Ocean Sciences as well as other Department of Fisheries and the Environment units in the Pacific Region. The system includes a main memory of 131K 36-bit words, approximately 47 million words of secondary drum storage, six magnetic tape units, three card-reader/line-printer combinations (one installed at Fisheries Operations in Vancouver), and some communications hardware. The operating system supports concurrent local batch, remote batch, and demand (time-sharing) processing and the software includes all the standard languages and many application packages.

Education of DFE personnel commenced in March with courses by Univac on the job control language. A resident systems analyst was assigned to DFE by Univac to assist with training and to eventually implement and support the operating system and associated software. Some users started conversion of programs to the Univac by utilizing an external service bureau (Digitech in Calgary) over the summer.

Although the Univac 1106 computer was delivered to the Patricia Bay site on May 31, building construction problems delayed completion of the installations until the end of September. The Univac was accepted as ready for use on October 12. Following an intensive course and a number of seminars, most on-site users began conversion of programs and data files in earnest during December.

Intermittent problems with Hydro power have been the major difficulty with the system. The Univac computer is particularly sensitive to short-duration transient voltage fluctuations, which

result in a CPU halt and the loss of all active runs. Although system restart is quite easy, a solution to this nuisance will be sought in 1977.

Other Developments

The computerized Financial Accounting and Reporting System was converted from a service bureau to an in-house mini-computer (HP 2100) by March. The Datapoint terminal, for off-line entry and editing of financial transactions, became operational in August. It is now possible to have a daily up-to-date picture of the financial status of the region and all collators.

Implementation of an Inventory Management System was nearly complete by the end of 1976. The system features interactive and batch entry of inventory data, and uses System 2000 for updating and maintaining the data base.

The Fortran HAAPS software was implemented and successfully used on Hydrography's PDP-8 computers during field operations. This is an improved system of routines for editing, processing, and plotting hydrographic data. It features reduced execution time and better algorithms to handle unusual conditions in the data than previous HAAPS programs. At year's end the Fortran HAAPS routines were being modified to handle data collected by the new PHAS micro-computer-based hydrographic data acquisition systems, which record on 3M cartridge drives.

Other mini-computer developments include: first use of Coastal Zone Oceanography's HP21MX processing system in the field; improved software and hardware (with assistance of Survey Electronics) for the translation of Aanderaa current meter tapes; provision of updated disc operating system software for the three disc-based HP 2100 series computers; improvements, extensions, and complete documentation for the Hp context editor.

Additional hardware acquired during 1976 includes: a large Tektronix graphical display terminal for Patricia Bay, allowing the small Tektronix to be connected to the Federal Building HP 2100; a new Versatec printer/plotter for the Patricia Bay HP 2116; four HP 2640 terminals to provide access to the Univac 1106 from Patricia Bay, the Pacific Forest Research Centre, and Fisheries Operations in Vancouver; four TI Silent 700 series terminals for access to the Univac computer.

Installation of the Univac 1106 increased the responsibilities of the senior Computing Services staff. K. Teng assumed the role of Centre Manager for the Departmental computer, R. Johns became Supervisor of Systems and Operations and D. Smith became Supervisor of Mini-Computer Systems.

MANAGEMENT SERVICES DIVISION

N.A. Todd - Chief of Management Services

Institute of Ocean Sciences

The last two annual reports have talked about audible and visible evidence that the new facilities at Patricia Bay were becoming a reality. During 1976 the whole Institute has taken shape, and a considerable part of it has been completed and put into use.

The wharf became fully operational early in the year. The ships began to use Patricia Bay as their home base when the new workshop-warehouse or depot building was turned over from the contractors in mid-June. At that time all of Ship Division moved to Pat Bay from Harbour Road. The new warehouse and central stores have rapidly taken on the appearance of all such spaces with shelves stacked with equipment.

The UNIVAC 1106 computer has been temporarily accommodated in the depot building. Providing power, air conditioning and other mechanical services for this regional computing centre has been a project in itself. The quality of the electrical power is perhaps the largest problem which hopefully will be finally resolved when the computer is moved to its permanent location in the main building.

The main building is well advanced. The basic steelwork and concrete work are all completed and the job of filling in the spaces is well underway. The project did suffer from a loss of three months through labour stoppages. This loss may, from our point of view, have been more apparent than real because the rate of construction progress was outrunning the allotted cash flow for the year.

The main complex will be finished sequentially. The first section is expected to be occupied in May 1977 by Ocean Physics. Next year's report should be able to start with a statement that all our staff are housed in their new quarters.

Administration

The administrative services carried on their function in the best traditions of the silent service. The computerized financial system has proved itself to be a reliable, economical and powerful management tool. Daily print-outs for allotment, commitment and expenditure controls are obtained.

Good progress has been made with the Computerized Materiel Management or inventory system. This has been developed in close cooperation with Computing Services and is designed to give a detailed yet flexible system serving our internal needs and those of the auditors.

Continuing man-year constraints are a problem here as elsewhere. The Section takes satisfaction in knowing that our administrative overhead stands up very well in comparison with other organization.

THE LIBRARY

Sharon Thomson - Librarian

The year 1976 was one of expansion in the responsibilities of the Library, while the difficulties inherent in our separated locations were still very evident.

Material of interest mainly to chemists is housed in the Ocean Chemistry Division, from whence it is retrieved for borrowers in other sections. The same conditions apply to items located with Frozen Sea Research Group. One half of a trailer at Patricia Bay serves as a repository for journals used by the clientele working on the site and it must seem to the office staff there that we will wear the things out transporting them from place to place and back again.

Two new groups were added to our library clientele in 1976 - an Ocean Ecology Group and an Arctic Marine Group. It was immediately apparent their needs for biological, ecological and arctic subject matter were not going to be met from a collection focussed on physics and chemistry. We quickly embarked on a buying program to supply these groups with the core materials in their specialties. The needs of 20 biologists are really not greater in terms of core material than the library requirements of one biologist. What is called in college library circles 'an opening day collection' is exactly what we must achieve for each of these groups - and at once!

We have added on-line literature searches to our services and the response of the users so far has been one of delight. We expect this service, which only started December 15, to be more widely used now that the 'bugs' are out and more people are aware that it is available.

Our losses from the collection are large and replacements will have to be made good once we are moved to the Institute. At that time we will be able to give proper care to the collection and to start a better circulation control system. These things are now much closer to reality since we have been advised that we may be moving as soon as August of 1977.

Persons and companies who have contracts with us expect support from our Library since we have the only oceanographic collection in the area. If their requests result in a direct expense to the Library we check with the contractor supervisor to be certain the request is a valid part of the contract.

No annual Library report would be complete without a remark or two on money. Libraries are very expensive and it must seem to the administration that they are insatiable in their demands for funds. However, as the cost of our paid subscriptions averages $100 per year and the cost of the types of monographs we buy approaches $25 per volume it is readily apparent that $25,000 per year will not adequately support a research collection which is growing and must continue to grow rapidly to be of real use to its patrons.

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent

F.S. Green - Assistant Marine Superintendent (deck)
D. Marr - Assistant Marine Superintendent (engineering)
G.R. Meek - Submersible Operations Manager

The Pacific Region Ship Division provided ship, submersible, launch and depot support for the 1976 hydrographic and scientific programs and for several federal departments and universities.

CSS PARIZEAU (64.3 m. overall, 1929 metric tons)

Master: A.G. Chamberlain Chief Engineer: R. Parkinson

Following annual drydocking and refit at Yarrows Ltd., Victoria, B.C. CSS Parizeau was employed in support of various scientific and hydrographic programs: P.E.I. ecology; I.O.U.B.C. biology, botany; D.R.E.P. ocean acoustics, towex; O. & A.S. ocean chemistry, coastal oceanography. She was converted to hydrographic configuration and sailed from Victoria for the Western Arctic, July 5, 1976, meeting the icebreaker CCGS J.E. Bernier at Icy Cape, July 15, 1976. The two vessels battled very heavy ice, reaching a position just north and east of Point Barrow. At this point Parizeau, due to severe damage to her propellors and rudder, had to cancel her hydrographic program and proceed south under tow of J.E. Bernier, to safe anchorage at Teller, Alaska. The CFAV sea-going tug St. Anthony towed Parizeau from Teller, Alaska to Yarrows Shipyard, Esquimalt, B.C. for repairs which proved difficult and time-consuming. The vessel returned to service on November 15, 1976.

CSS WM. J. STEWART (65 m., 1720 tonnes)

Master: K.J. Sjoholm Chief Engineer: J.D. Henderson

The Wm. J. Stewart was not commissioned in 1976, because of severe manpower restrictions. The ship was towed to the new Institute wharf at Patricia Bay in June, where she accommodates the Ship Division offices.

CSS VECTOR (39.6 m., 505 tonnes)

Master: J.C. Marston Chief Engineer: J. Peat

The CSS Vector's annual drydocking and refit was carried out at Yarrows Ltd. During the year she carried out the following programs without interruption: S.F.U., biology; I.O.U.B.C. biology, physics; U.Vic, biology; E.M. & R. geology; P.E.I. ecology, biology; E.P.S. biology; O. & A.S. tides and currents, ocean chemistry.

CSS RICHARDSON (19.8 m., 76 tonnes)

Master: M.G. Wheeler   Chief Engineer: I.N. Henderson

The CSS Richardson's drydocking and refit was carried out at Sterling Shipyard, Vancouver, B.C. Following refit she was used in full support of the following programs: O. & A.S. hydrography and side scan sonar.

C.F.A.V. LAYMORE (53.6 m., 645 tonnes) Dept. of National Defence

Master: M.J. Dyer   Chief Engineer: H.R. Doherty

From January 1 to February 15, 1976 Laymore was used on the following programs: I.O.U.B.C. biology; P.E.I. biology; D.R.E.P. ocean acoustics. The Laymore was taken out of service and decommissioned February 15, 1976.

M/V RADIUM EXPRESS (22.2 m., 100 tonnes) on charter

Master: J.P. O'Sullivan   Chief Engineer: W. Riggs

The hydrographers reported a successful survey season with the Radium Express, covering the Mackenzie River from Hay River to the Mackenzie Delta and the Eskimo Lakes.

M/V PANDORA II (58.2 m., 2,200 tonnes) on charter

Master: R. Jones   Chief Engineer: C. Tuck

The Pandora II's area of operations for the year 1976 was along the B.C. Coast, and with Pisces IV she was employed in the following programs: E.P.S. biology; D.R.E.P. underwater cable inspection, ocean acoustics; U. Vic. biology; E.M. & R. geology; D.N.D. Voodoo Aircraft search; P.B.S. biology; O. & A.S. tides and currents, ocean physics, diver training and certification.

PISCES IV (6.1 m., 12 tonnes)

Operations Officer: G.R. Meek   Chief Pilot: I. Sanderson

Pisces IV, the deep-dive submersible, underwent annual refit and was employed in various scientific programs with Pandora II. She was also employed in a search for a missing Voodoo aircraft. The aircraft was not located.

C.S.L. REVISOR (11 m., 10 tonnes)

The launch Revisor was actively engaged in revisory surveys in various locations along the B.C. south coast.

LAUNCHES

Survey launches were fully employed by shore-based hydrographic survey parties working in the Gulf of Georgia and Ucluelet areas.

DEPOT

The depot workshops facility continued its full support to all Institute groups. The depot was moved from Harbour Road, Victoria, B.C. to the new workshops facility at I.O.S. Patricia Bay in June, 1976. This move was completed in one working week and support services were carried on without interruption.

E.N. Geldart, Regional Marine Superintendent, in his temporary office on board CSS Wm. J. Stewart

SCIENCE CONTRACTING

G.R. Smith - Industrial Liaison Officer

In 1976-77 the value of science-related contracts to industry for the Institute exceeded $1 million. This is 10 times the expenditure in 1972 when a contracting-out policy was implemented and is a 45 per cent increase over 1975-76. Contracting scientific activities has involved learning for both government scientists and industry. The response of Institute staff has been very encouraging. They have recognized the value of technical support from the private sector, and as a result industry is increasingly involved in Institute field projects. More than half of the science-related contracts are funded directly from the budgets of individual Sections.

The results of the efforts by the Institute, over the past few years, to implement federal government policy by developing commercial oceanographic services in Western Canada, are beginning to show. Industry has improved its capability in both field work and data analysis. An indication of success is that a number of companies now employ full-time oceanographers, and a market for oceanographic services is developing within the private sector. Oceanography should soon be a fully viable commercial activity on the Pacific Coast of Canada, with resulting benefit to the regional economy as well as an enhanced ability to deal with marine pollution and other environmental problems.

SCIENCE RELATED CONTRACTS AWARDED IN 1976

Ocean Dumping Program

To provide a basis for the regulation of ocean dumping on the Pacific coast.

		Total Amount
1.	Study of the effects of dumping dredge spoils containing wood debris on the benthic community in Alberni Inlet. Dobrockey Seatech Ltd.,Victoria,B.C.	$ 32,130
2.	Toxicity of leachates from dredge spoils containing wood wastes. EVS Consultants Ltd.,Coquitlam,B.C.	8,147
3.	Chemical and physical analysis of samples containing wood debris. Econotech Services Ltd.,New Westminster, B.C.	11,070
4.	Ocean Dumping Training manual. Valerie Bradshaw, Vancouver, B.C.	4,500
5.	Evaluation of additional data from Point Grey dumpsite. Seakem Oceanography Ltd., Victoria, B.C.	2,357
6.	Mercury mobilization from resuspended dredge spoils. Seakem Oceanography Ltd., Victoria, B.C.	21,514
7.	Collection of sediment samples at Mamquam Channel. Chemex Labs.Ltd., North Vancouver, B.C.	4,762
8.	Heavy metals in marine benthic organisms at the Point Grey dumpsite. Cantest Ltd., Vancouver, B.C.	2,038

9.	Biotransformation of inorganic mercury to organo-mercurials in Mamquam Channel sediments. Willis Cunliffe Tait & Co.Ltd., Victoria, B.C.	8,900
10.	Design of a benthic corer for Pisces IV. Canadian Aircraft Products, Richmond, B.C.	5,500
11.	Investigation of coring techniques for areas with extensive wood debris. B.H. Levelton & Associates Ltd., Victoria, B.C.	8,000
12.	Core samples from Mamquam Channel. B.C. Research, Vancouver, B.C.	1,650
13.	Establishment of a tentative oxygen budget for Alberni Inlet. Seakem Oceanography Ltd., Victoria, B.C.	2,000

Pacific Coast Program

To contribute to a basis for meeting Institute responsibilities in Pacific marine waters.

14.	Identification of ecological indicators of ocean mixing in Haro Strait. Dobrocky Seatech Ltd., Victoria, B.C.	8,988
15.	Baseline sampling of marine benthic fauna in Saanich Inlet. Beak Consultants, Ltd., Vancouver, B.C.	9,985
16.	Identification of benthic samples. Envirocon Ltd., Vancouver, B.C.	1,309
17.	Sample analysis to investigate distribution of benthos in relation to ocean dumping. P.Chapman, Victoria, B.C.	3,240
18.	Sample analysis to investigate distribution of benthos in relation to ocean dumping. W.Carolsfeld, Victoria, B.C.	5,760
19.	Digestion in pollution-indicating sludge worms. N.Kaushik, Guelph, Ont.	6,500
20.	Analysis of lighthouse oceanographic data. I.Webster, West Vancouver, B.C.	3,440
21.	Analysis of lighthouse oceanographic data Phase III. Associated Engineering Services Ltd., Vancouver,B.C.	16,064
22.	Placing and recovery of an experimental instrument mooring. Dobrocky Seatech Ltd., Victoria, B.C.	4,500
23.	Experimental mooring of current meters to test cable fairing. Dobrocky Seatech Ltd., Victoria, B.C.	8,500
24.	Feasibility and design study for a profiling current meter platform. Canadian Thin Films Ltd.,N.Vancouver, B.C.	8,000
25.	Updating computer system software to achieve compatibility of context editor at the Institute of Ocean Sciences.	2,136

26.	Provision of computer operations services for Dept. of Environment, Pacific Region Computing Centre. Ronor Management Ltd., Ganges, B.C.	32,702
27.	Development of a computer program for Ocean Mixing. Apocalypse Enterprises Inc., Victoria, B.C.	17,976
28.	Development of computer programs for hydraulic research. Apocalypse Enterprises Inc., Victoria,B.C.	17,789
29.	Development of computer program for Remote Sensing. Apocalypse Enterprises Inc., Victoria, B.C.	11,960
30.	Provision of field support for geological surveys in the Fraser River and Georgia Strait. Dobrocky Seatech Ltd., Victoria, B.C.	21,288
31.	Study of the Squamish estuary by means of aerial photography to assess the effect of port construction. Pacific Survey Corp., Vancouver, B.C.	746
32.	Water properties sampling and measurement program aboard CCGS Vancouver and Ocean Station P. Seakem Oceanography Ltd., Victoria, B.C.	47,825
33.	Evaluation of water samplers for analysis of trace metals and hydrocarbons in sea water. Seakem Oceanography Ltd., Victoria, B.C.	10,673
34.	Field support for chemical oceanography and sampling in Georgia Strait. Dobrocky Seatech Ltd., Victoria, B.C.	10,500
35.	Assistance in organizing and participation in the CEPEX field experiments. Thalassic Data Ltd., Vancouver,B.C.	6,027
36.	Oceanic water properties sampling and measurements aboard CCGS Quadra and chemical analysis of sea water in shore laboratories. Seakem Oceanography Ltd., Victoria, B.C.	63,972
37.	Deployment of CEPEX bags. Case Existological Laboratories Ltd., Victoria, B.C.	2,250
38.	Development of techniques for extraction of lead in tuna fish and mercury extraction method for marine sediments. J.Alix, Victoria, B.C.	1,659
39.	Development of analytical techniques for measurement of concentration of natural and anthropogenic hydrocarbons in seawater, marine organisms and marine sediments. Dr.P.Christensen, Victoria, B.C.	4,500
40.	Analysis of Ocean Chemistry plankton samples from the CEPEX CO_2 project. J.Chang, Port Hardy, B.C.	3,000
41.	Service to coat all lead diving weights with epoxy paint for CEPEX bag deployment. Case Existological Laboratories Ltd., Victoria, B.C.	1,000
42.	Physical oceanography of Haro Strait. Dobrocky Seatech Ltd., Victoria, B.C.	72,000

43.	Examination of the movements of oceanic fronts in Haro Strait. S.Yee, Sidney, B.C.	2,700
44.	Data survey and recommendations for an oceanographic study of Haro Strait. Associated Engineering Services Ltd., Vancouver, B.C.	7,096
45.	Computer sorting of hydrographic data. Apocalypse Enterprises Inc., Victoria, B.C.	443
46.	Revision of Canadian Hydrographic Service charts and the supply of information for B.C. Sailing Directions. I.Campbell, Sidney, B.C.	2,000
47.	Study of the feasibility of using photogrammetric techniques to obtain data necessary to generate hydrographic charts. (Aerial Hydrography Project) Dr. S.E. Masry, Fredricton, N.B.	16,800
48.	Development of computer programs for field hydrography. Apocalypse Enterprises Inc., Victoria, B.C.	4,875
49.	Specialized revision of hydrographic charts. Case Existological Laboratories Ltd., Victoria, B.C.	32,619
50.	Contouring of computer-sorted hydrographic data. Dataplotting Services Ltd., Don Mills, Ont.	500
51.	Oceanographic water properties sampling and measurements aboard CCGS Quadra. Seakem Oceanography Ltd., Victoria, B.C.	3,877
52.	Biological and oceanographic research support. University of Victoria, Victoria, B.C.	8,000
53.	Oceanographic support to the Institute of Ocean Sciences. Dobrocky Seatech Ltd., Victoria, B.C.	33,000
54.	Research study on shelf wave propagation along the B.C. coast. L.A.Mysak, Vancouver, B.C.	5,000
55.	Cooperative research on fjord dynamics. University of B.C., Vancouver, B.C.	17,204
56.	Development of improved airfoil probes for oceanographic measurements. University of B.C., Vancouver, B.C.	5,000
57.	Feasibility study of deploying drifting buoys from islands during the First Global Experiment - part of the Global Atmospheric Research Program (GARP). Beak Consultants Ltd., Vancouver, B.C.	8,000
58.	Study of chlorophyll concentrations in seawater. R.A. Neville, Sidney, B.C.	12,900
59.	Numerical modelling of the movement of the Fraser River discharge in the southern Strait of Georgia. University of B.C., Vancouver, B.C.	3,075
60.	Preparation of zooplankton species reference collection. University of B.C., Vancouver, B.C.	325

61.	Analysis of oceanographic data from weathership cruises. G.C.Jewsbury, Victoria, B.C.	3,150
62.	Analysis of Patricia Bay sediment samples. Chemex Ltd., N.Vancouver, B.C.	484
63.	Preparation of oceanographic data in digital form for the Fraser River plume. University of B.C., Vancouver, B.C.	1,012
64.	Airborne thermal scanning of Haro Strait. Intera Environmental Consultants Ltd., Calgary, Alta.	2,155

Arctic Program

To contribute to a basis for meeting Institute responsibilities in Arctic marine waters.

65.	Installation and recovery of wave rider buoys in the southern Beaufort Sea. Seakem Oceanography Ltd., Victoria, B.C.	2,410
66.	Study on sea-ice distribution and sea-ice-air interaction. G.Bugden, Victoria, B.C.	350
67.	Study of beluga and bowhead whales in the southern Beaufort Sea. F.F. Slaney and Co.Ltd., Vancouver, B.C. Funded by Beaufort Sea Project.	9,000
68.	Overview study and report related to the fate of oil in sea ice. A.L. Watson, Victoria, B.C. Funded by Beaufort Sea Project.	9,875
69.	Analysis of oceanographic field data from Canadian Arctic Archipelago. D.Fissel, Victoria, B.C. Funded by Environmental Protection Service.	15,350
70.	Radar tracking of ice in Byam Martin area. Seakem Oceanography Ltd., Victoria, B.C. Funded by DINA.	20,762
71.	Assembling and analysis of Arctic oceanographic data. G.R. Wilton, Victoria, B.C. Funded by DINA.	19,880
72.	Satellite image analysis and ice forecast evaluation pertaining to the Canadian Arctic Archipelago. J.R. Marko, Victoria, B.C. Funded by DINA.	22,000
73.	Overflight studies of spring breakup of transition zone ice in the Beaufort Sea. NORCOR Engineering and Research Ltd., Yellowknife, NWT.	23,952
74.	Field studies in the seasonal and permanent polar ice pack of the Beaufort Sea. NORCOR Engineering and Research Ltd., Yellowknife, NWT.	84,913
75.	Development of a scientific oilspill response plan for the Beaufort Sea. LGL Ltd., Edmonton, Alberta. Funded jointly by DINA and OAS.	19,630

76.	Preparation of a selective annotated bibliography of the biology of Lancaster Sound and vicinity. LGL Ltd., Edmonton, Alberta. Funded by DINA.	13,374
77.	Analysis and dating of Beaufort Sea surface sediment samples by lead-210 method. Thalassic Data Ltd., Vancouver, B.C.	4,800
78.	Modification and testing of Beaufort Sea meteorological model. Atmospheric Dynamics Corp., Elmira, Ont.	2,975

Unsolicited Proposals

Contracts supervised by the Institute for the Department of Supply and Services.

79.	Improvement of high speed acoustic telemetry link on present current meter systems. Caulfield-Liron Consultants, Edmonton, Alberta. Funded by DSS.	123,500
80.	The evaluation of a multi-beam sonor as a new hydrographic survey system. McElhanney Offshore Surveying and Engineering Ltd., Vancouver, B.C. Funded by DSS.	104,420
	TOTAL	1,164,263

Camp on Byam Martin Island was used for field studies in August and September by Arctic Marine Science group measuring surface currents by tracking ice floes with radar.

TASK FORCE, COMMITTEE AND SIMILAR ACTIVITIES

R.W. Stewart

Joint Organizing Committee (JOC) of the Global Atmospheric Research Program (GARP)

Canadian National Scientific Committee for GARP

Scientific Committee on Oceanic Research (SCOR) - member executive committee

SCOR - IAMAP - IAPSO Working Group on Air-Sea Interaction Research (COSPAR) - Canadian delegate

Sea Use Council (Canada-USA) - vice-chairman

Regional Board, Pacific Region (DOE)

Regional Board, Pacific Region, Executive Committee

Regional Board, Western and Northern (DOE)

National Research Council of Canada - GARP Grants Advisory Committee

Physical Oceanographic Commission (IAPSO) - president

Beaufort Sea Steering Committee - chairman

Arctic Environmental Steering Committee

Arctic Waters Oil and Gas Advisory Committee

Royal Society of Canada Interdisciplinary Selection Committee

W.N. English

Advisory Board on Marine Technology, B.C. Research Council

Pacific Sub-Committee on Oceanography

Regional Board, Pacific Region (DOE) - alternate

Pacific Region Board Working Group on Abatement of Pollution from DOE Ships - chairman

Regional Board, Pacific Region, Estuary Working Group

Sea Use Council (Canada-USA) - alternate

Military Colleges Advisory Board

Regional Ocean Dumping Advisory Committee

FMS Study Team on Future Direction of FRB - chairman

Federal-Provincial (B.C.) Fisheries Committee

HYDROGRAPHIC DIVISION

Ages, A.B.
- Environmental Emergency Working Group, Victoria Zone
- Coastal Water Pollution Group, Committee on the Challenges of Modern Society, NATO
- Technical Committee (DOE), Annacis Island Sewage Treatment

Bolton, M.
- Canadian Institute of Surveying - Councillor-at-Large
- DOE Kitimat Oil Pipeline Working Group
- DOE Mackenzie Basin Committee
- Hydrographic Committee CIS - chairman
- National Cartographic Appraisal Board
- National Hydrographic Survey Officers' Appraisal Board
- National Hydrographic Training Committee
- New Research/Survey Vessel Users Design Committee - chairman
- Pacific Sub-Committee on Oceanography of CCO - alternate
- Research Ship Scheduling Committee
- Joint DOE/DEMR Guiding Committee of Offshore Surveys

Curran, T.A.
- Electronics Advisory Committee, Camosun College

Huggett, W.S.
- New Research/Survey Vessel Users Design Committee
- Environmental Emergency Working Group, Victoria Zone

O'Connor, A.D.
- Canadian Institute of Surveying, Victoria Branch - chairman

Rapatz, W.J.
- B.C. Civil Defense Tsunami Committee
- Ocean Dumping Act - inspector
- Canadian Hydrographers Association - national president

Sandilands, R.W.
- Hydrographic Technical Committee, Canadian Institute of Surveying
- The Canadian Surveyor - associate editor (hydrography)
- Canadian Hydrographic Association - associate editor
- Survey Technology Advisory Committee, Camosun College
- Workshop Group on Offshore Surveys for Mineral Resource Development
- Board of Trustees, Maritime Museum of B.C. - chairman
- International Hydrographic Technical Conference Committee (1979)-member

Smithers, F.R.
- Public Information Group, DOE Pacific
- Regional Committee on Interagency Routing of Navigational Information

Watt, J.V.
- Aerial Hydrography Project Sub-Committee of Oceanography Working Group of CACRS
- Electronics Advisory Committee, Camosun College

Wills, R.
- Regional Hydrographic Survey Officers' Appraisal Board - chairman
- Regional Committee on Interagency Routing of Navigational Information
- Survey Technology Advisory Committee, BCIT
- Regional Board, Pacific Region, Estuary Working Group

OCEAN CHEMISTRY DIVISION

Cretney, W.J.
- Ph.D. Dissertation Committee - D.R. Green at UBC
- Working Group on Laboratory Waste Disposal, Pacific Region
- Laboratory Safety Committee, Ocean Chemistry - chairman

Wong, C.S.
- Advisory Committee - Chemistry, CEPEX
- Ocean Dumping Technical Committee, Pacific Region
- Ph.D. Dissertation Committee - D.R. Green at UBC

OCEAN PHYSICS DIVISION

Brinkhurst, R.O.
- Honorary Professor, University of Victoria, Department of Biology
- Thesis Committees, University of Victoria
- Canadian Society of Zoologists, Science Policy Committee - chairman
- Biological Council of Canada
- Science Subvention Program Review Committee, Fisheries and Marine Service
- Ocean Dumping Technical Committee

Farmer, D.M.
- Babine Lake Steering Committee
- RODAC Technical Subcommittee
- Canadian Meteorological Society, Oceanographic Division - chairman

Garrett, J.F.
- International Council of Scientific Unions Committee on Space Research (COSPAR), Committee for Use of Satellites for Oceanography
- Canadian National Committee for Scientific Committee on Oceanic Research
- GARP Committee for Drifting Buoys

Giovando, L.F.
- Joint Working Committee Lower Fraser River Environmental Monitoring
- B.C. Coastal Zone Resource Subcommittee

Gower, J.F.R.
- Canadian Advisory Committee on Remote Sensing, Working Group on Oceanography - chairman
- National Research Council Associate Committee on Space Research
- NASA SEASAT Synthetic Aperture Radar Experiment Team - associate member
- DOE Committee on Remote Sensing

Lewis, E.L.
- UNESCO/SCOR/IAPSO/ICES Joint Panel of Experts on Oceanographic Tables and Standards (SCOR W.G.10)
- SCOR/IAPSO Working Group 51 - "Evaluation of CTD Data"
- Panel on Ice - Arctic Oceanography Subcommittee, Canadian Committee on Oceanography
- Marine Science Communications - Editorial Advisory Board

Milne, A.R.
- Beaufort Sea Project - manager
- Arctic Islands Pipeline Program - board member
- Arctic Region Ocean Dumping Committee
- SEASAT Working Group on Ice
- Task Force on Energy-Related Baseline Studies

Miyake, M.
- Canadian GARP Coordinating Committee
- Canadian GARP Scientific Committee
- NCAR Aircraft Facility Evaluation Committee
- Executive Committee Mixed Layer Experiment, U.S. Office of Naval Research
- Committee for Long-Range Transport of Air Pollutants

Nasmyth, P.W.
- IGOSS Group of Experts on Technical Systems Design and Development and Service Requirements - chairman

Tabata, S.
- Ocean Climatic Panel of Working Group 34 of the Scientific Committee on Oceanic Research (SCOR)

Thomson, R.E.
- British Columbia Coordinating Climate Committee
- Initial Environmental Assessment Study Group on the proposed Burrard floating drydock and ship repair facility

OCEAN ENGINEERING

Teng, K.
- West Coast Electronic Data Processing Coordinating Committee, DOE
- Canadian Information Processing Society, Victoria Section - program chairman
- Organizing Committee for CIPS/ACM Northwest 78 Regional Conference - co-chairman

Johns, R.E.
- West Coast Electronic Data Processing Coordinating Committee, DOE
- Univac Scientific Exchange - installation representative

SHIP DIVISION

Geldart, E.N.
- Pacific Regional Resource/Survey Vessel Committee - secretary

Institute of Ocean Sciences, Patricia Bay, 1975 Annual Report.

PACIFIC MARINE SCIENCE REPORTS

<u>PMSR 76-1</u>
Twaites, B.L., K.A. Coates, C. de Jong — Oceanographic observations at Ocean Station P (50°N,145°W) volume 64, 10 January-19 February 1975.

<u>PMSR 76-2</u>
de Jong, C. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 65, 14 February-2 April 1975.

<u>PMSR 76-3</u>
Smyth, T.A., G.W. Arminini, C. de Jong — Oceanographic observations at Ocean Station P (50°N,145°W) volume 66, 28 March-14 May 1975.

<u>PMSR 76-4</u>
Brinkhurst, R.O. — Aquatic Oligochaeta recorded from Canada and the St.Lawrence Great Lakes.

<u>PMSR 76-5</u>
Ages, Alard and Anne Woollard — The tides in the Fraser Estuary.

<u>PMSR 76-6</u>
Fissel, D.B. and W.S. Huggett — Observations of currents, bottom pressures and densities through a cross-section of Juan de Fuca Strait.

<u>PMSR 76-7</u>
Bell, W.H., D.M. Farmer, G.R. Kamitakahara — A field translation system for Aanderaa data tapes.

<u>PMSR 76-8</u>
Landry, L.P. — Radar tracking of drift drogues in Pendrell Sound and Port Mellon June and September 1974.

<u>PMSR 76-9</u>
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<u>PMSR 76-10</u>
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<u>PMSR 76-11</u>
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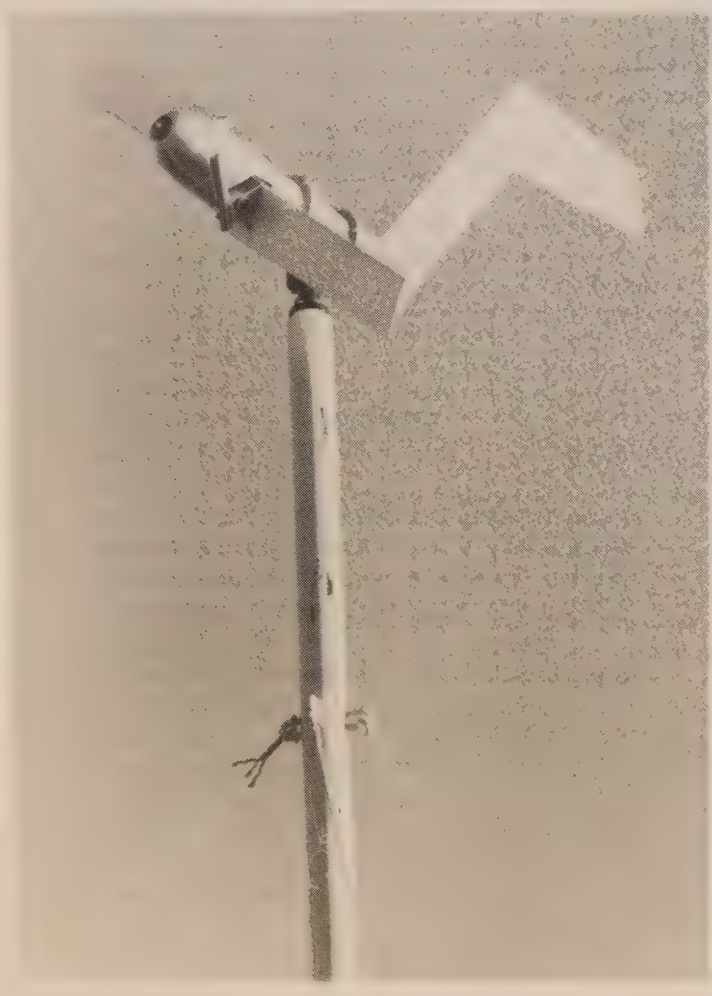

Windmill being tested for possible use as a wind-powered battery charging source for transponders on hydrographic surveys at remote sites.

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Wakefield, L.M.

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Chan, C.C.	Engineer 1st Class Motor; Relief Engineer

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Clarke, L.E.	Supply Officer
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Kyle, R.G.	Engineer 2nd Class Motor; Senior Engineer
Orr-Hood, J.	Engineer 4th Class Motor; 2nd Engineer

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Easson, R.J.	Master, F.G.; 1st Officer
Palmer, S.	Supply Officer
Gibson, R.B.	Engineer 3rd Class Steam; Senior Engineer
Conway, A.	Engineer 4th Class Combined; 2nd Engineer

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CSS RICHARDSON

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Henderson, J.N.	Engineer 4th Class Motor; Chief Engineer

MV RADIUM EXPRESS

O'Sullivan, J.	Master
Butler, W.	Chief Engineer

MV PANDORA II (Charter)

Jones, R.	Master
Tuck, C.	Chief Engineer

PISCES IV

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Sanderson, I.	Chief Pilot
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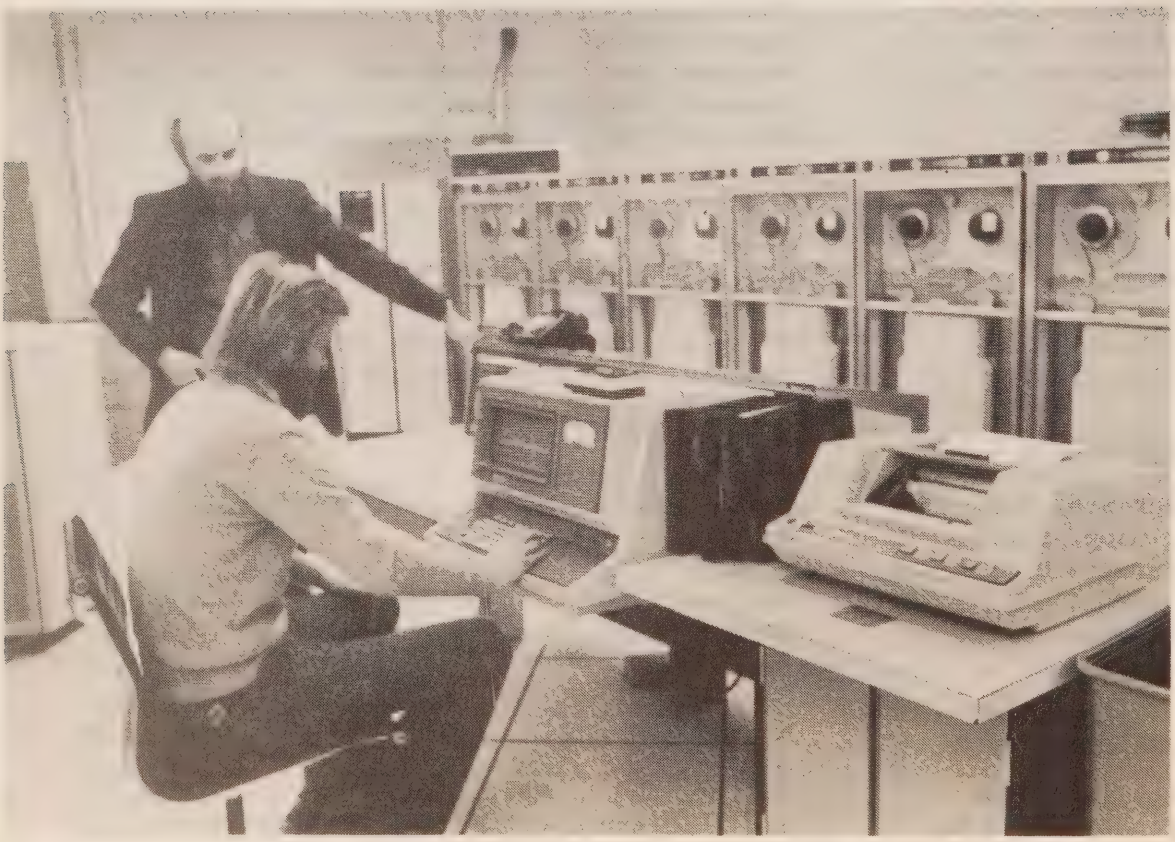
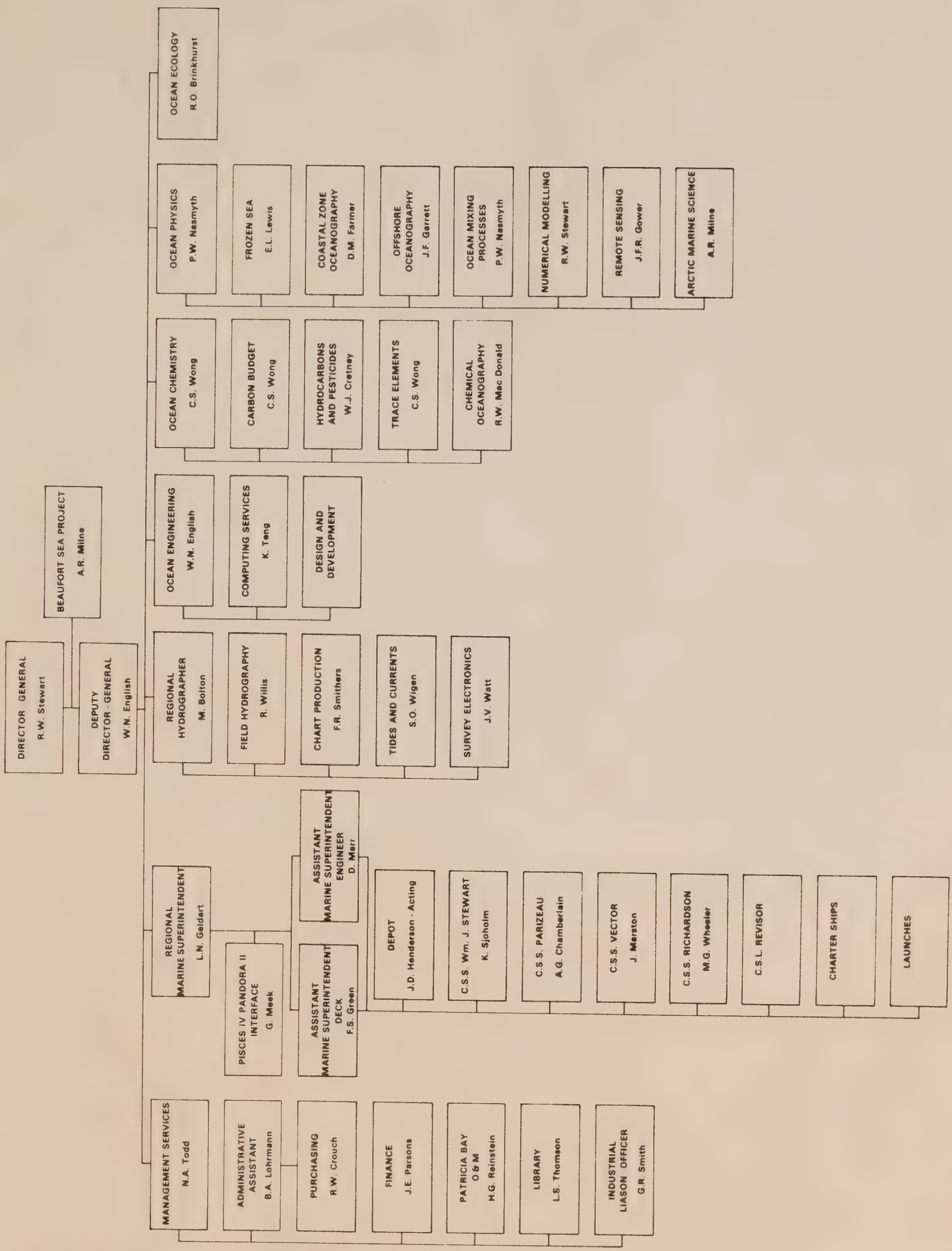
Taylor, R.H.	Pilot
Jacobson, R.	Pilot
Gaudreault, J.	Pilot
Grant, D.	Pilot



Regional Computing Centre for DFE was
installed at Patricia Bay during 1976.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INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT - 1977

INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY
Sidney, B.C.

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INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY

ANNUAL REPORT 1977

Sidney, B.C.

March, 1978

CONTENTS

DIRECTOR-GENERAL'S OFFICE

R.W. Stewart

T. Van Dusen A.B. Cornford

The year 1977 will almost certainly go down in the annals of the Institute of Ocean Sciences, and remain in the memories of many of those of us who make up the Institute, as the year of our new building. Although the Depot building was finished in 1976, and most of Ocean Physics had been working at Patricia Bay for some time, it was in 1977 that the move was really effected. In May, as planned, the major part of the Quadrangle building was occupied. We were brave (perhaps foolhardy) enough to schedule a major international meeting -- the Executive of the Scientific Committee on Oceanic Research -- for the week we took the building over. Perhaps surprisingly, both the move and the meeting went quite smoothly.

In September the Hydrographic Division and Management Services Division moved out from the top floor of 1230 Government Street which had housed them for so long. Those of us who worked downtown will miss Bastion Square, the pleasant choice of little restaurants and boutiques and the possibility of noonhour and afterhour shopping in downtown department stores. However we have the compensation of our fine new quarters with their resort hotel setting, of ready access to our ships, to aircraft and to the ferries and even more of the ready access to our colleagues. It is certainly easy to find some nostalgia for the former arrangements, but on balance it seems that few people regret the change.

With the move of Ocean Chemistry in January 1978 and the arrival of the contingent from the Department of Energy, Mines and Resources in February all of the planned units will be in place.

We have ourselves a remarkable and unique structure. Those of us who have seen other Federal Government buildings around the country, a large proportion of which seem to have been designed to be defended in case of riot or insurrection, can only rejoice at the amount of light and air we have, the number of mature trees in our view, and the generally rural aspect which we can expect when the landscaping is complete.

Already the numbers of touring visitors is having some negative impact on our work. We can only expect this number to increase. However as we become accustomed to these visitors and learn better how to handle them, the interference with our work should dwindle.

Fortunately the trauma of moving seems not to have interfered to the degree that many had feared with our going about our business. In many cases the interruption in work hardly amounted to more than a day or so. In most it was a matter of a week or so. Our charts continued to be produced and to be sold. Our surveys got done -- even the Arctic ones this year where the *Pandora II* proved to be a substantially more effective vessel than many had expected. Tides and currents were measured and analysed, oceanographic and environmental impact work continued unabated in coastal waters, in the northeast Pacific and in the Arctic. The following pages will identify highlights of these accomplishments.

R.W. Stewart

Aerial view of the Institute of Ocean Sciences, Patricia Bay, October 1977

HYDROGRAPHIC DIVISION

REGIONAL HYDROGRAPHER

M. Bolton - Regional Hydrographer

D. Van Aanhout

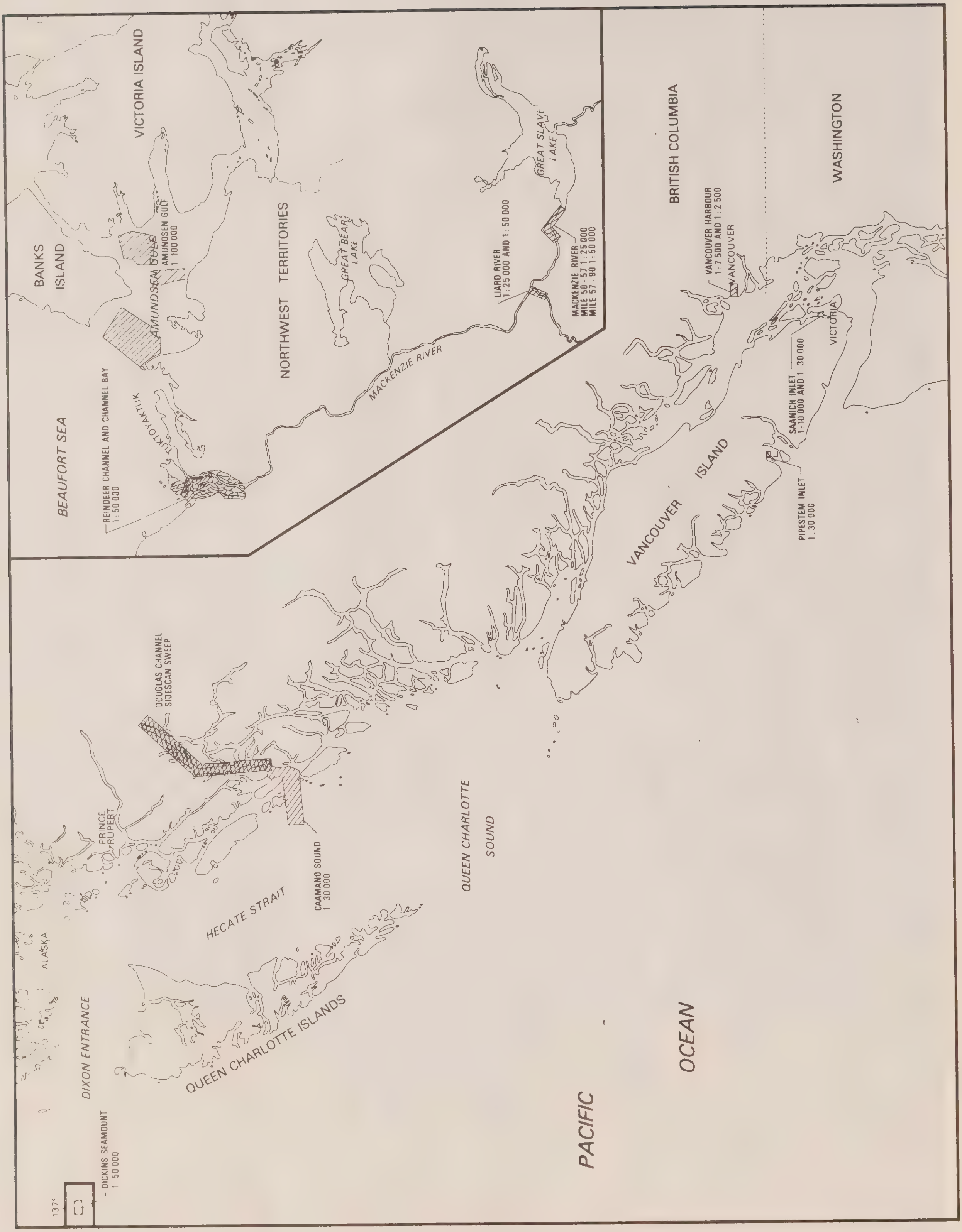
In early September the long anticipated move to new facilities at the Institute of Ocean Sciences at Patricia Bay occurred. The new location, about 30 km north of downtown Victoria, brings together all the Hydrographic Sections, and all of the essential support facilities in one modern complex, immediately adjacent to our ships and wharf. Aside from the obvious advantages of close proximity to all ship and support services the housing of oceanographers and hydrographers under a single roof will ensure closer program and scientific cooperation and coordination.

Investigations of real and potential tanker traffic routes demanded considerable effort from both Field Hydrography and Tidal and Current Surveys. Not only were field programs undertaken in Queen Charlotte and Caamano Sounds but additionally, considerable input was provided towards evaluation of the TERMPOL submission for Kitimat and towards the West Coast Oil Port Risk Analysis Study.

In 1977 a successful field program, involving the Department of Energy, Mines and Resources and Ocean Chemistry as well as Field Hydrography, was completed in the Western Arctic from the charter vessel *Pandora II*. Good ice and weather conditions were major contributing factors.

The acquisition and installation of a flatbed plotting system in the Institute has begun to greatly facilitate our chart construction activities. Plans for the purchase of a complete digitizing system are well underway and with the acquisition and installation of this equipment the first stages of transition to automated cartography are approaching their reality.

During the year extensive resources of both manpower and equipment were devoted to calibration of the new Canadian West Coast Loran-C Chain.



Field survey operations 1977

FIELD HYDROGRAPHY SECTION

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G.H. Eaton
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P.R. Milner
A.R. Mortimer
A.D. O'Connor
R.D. Popejoy
M.L. Preece
*L.E. Prussner
A.R. Raymond
G.E. Richardson
+E.D. Sargent
R.U. Schoenrank
C.R. Tamasi
J. Vosburgh
+M.M. Ward
*J.G. Wanamaker
D.J. Wood
M.V. Woods

* Left during 1977
\+ Joined during 1977

R.W. Sandilands - Head Sailing Directions
J.W. Chivas
L.M. Wakefield

J.B. Larkin - Head Hydrographic Development
A.J. D'Aoust
**F.A. Coldham
**R.D. Popejoy

**Rotational Staff on Hydrographic Development

A major effort in 1977 was devoted to the calibration of the new Canadian West Coast Loran-C Chain. This entailed cruises on *Parizeau, Vector* and *Pandora II*, as well as truck and helicopter operations to the B.C. interior, Williams Lake and George, Washington. The data collected, and now being processed, is essential to ensure the proper construction of chart lattices and, in addition, will provide the material for at least five important reports. This was a cooperative project involving, in addition to regional resources, the Nautical Geodesy Division at Headquarters, Ottawa, the Navigation Group at the Atlantic Oceanographic Laboratory, Central Region, Canadian Hydrographic Service, the Canadian Coast Guard, the U.S. Coast Guard and the Pacific Centre of the National Ocean Survey at Seattle.

A major resurvey of Vancouver Harbour was undertaken and the main area between First and Second Narrows was completed. In view of the possible development of Kitimat as a supertanker port, a new survey of Caamano Sound was completed by C.S.S. *Parizeau*, and C.S.S. *Richardson* which carried out a side scan sonar sweep of most of the route to Kitimat, though

additional areas remain to be swept in 1978 if all possible routes are to be covered. The field sheets of the side scan sonar sweeps are unique for this region, showing extensive bottom characteristics as well as depth. Surveys of Pipestem Inlet and Effingham Inlet in Barkley Sound were completed as well as some final work to complete modern surveys of Saanich Inlet.

Pandora II at anchor in Amundsen Gulf in 1977

Pandora II had a successful season in the western Arctic conducting multi-disciplinary surveys in Amundsen Gulf, also completing a survey of Dickins Seamount and carrying out GEBCO (General Bathymetric Chart of the Oceans) sounding and Loran-C checks en route.

The contract for Revisory Surveys (Charts and Sailing Directions) was increased to cover most of the southern B.C. coastal waters, and was the only such operation carried out by the Region in 1977.

Annual surveys of the Athabasca-Mackenzie Waterway were continued by *Radium Express* with emphasis on the delta areas. Soundings were acquired on the Liard River at the confluence of the Mackenzie mainly in support of studies being conducted by the Glaciology Division of the Department of Energy Mines and Resources. Photographic surveillance of artificial islands in the Beaufort Sea was maintained with flights in early July and late September.

In preparation for next year's offshore surveys, geodetic positions were established on mountain tops on the west coast of the Queen Charlotte Islands, employing two satellite positioning systems.

Sailing Directions

The third edition of Small Craft Guide, Volume I was published early in the year. The limits of this publication were extended to include Port Alberni to Sooke and Nanaimo to Campbell River.

The second edition of Small Craft Guide, Volume II has been revised and expanded to give coastal coverage to Prideaux Haven. It is due from the printers early in 1978.

These two companion volumes now give small craft coverage for the southern waters where the majority of recreational boating takes place in British Columbia.

The seventh edition of B.C. Sailing Directions (North Portion) Volume II has been revised and is also due from the printers early in 1978.

Mr. Chivas joined C.S.S. *Parizeau* in March for a field inspection of portions of the northern coast including the west coast of Queen Charlotte Islands while the ship was on an oceanographic cruise. He returned with first-hand information for inclusion in sailing directions.

The section participated in a contract for Revisory Surveys and obtained information on new facilities and field sailing direction revisions in the Strait of Georgia and the inside coastal waters as far as Rivers Inlet.

Hydrographic Development

A. D'Aoust, who joined the development group late in 1976, moved to Victoria in November after being seconded to Canada Centre for Remote Sensing in Ottawa for one year to participate in the Aerial Hydrography Project.

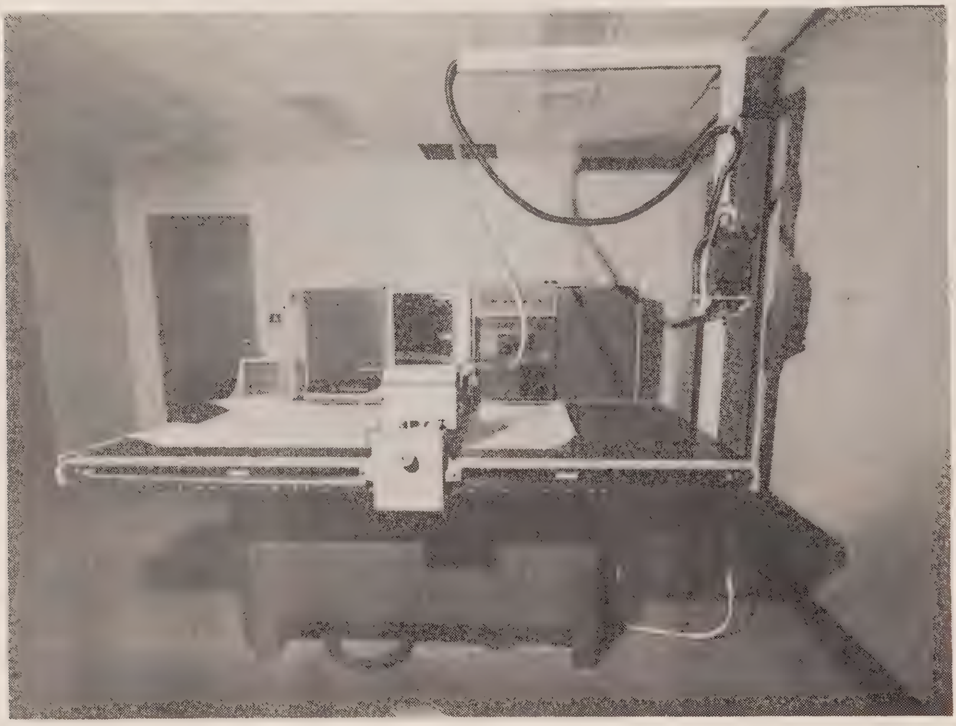
In the spring, flight tests were conducted over the Casa Grande Military Photo Test Range in Arizona. During the summer these data were analyzed, and preparations made for over water flight tests in Pacific Region in the fall. The development group conducted control surveys at three areas, then placed and maintained ground targets during the flights.

In preparation for the hydrographic field season, R. Tamasi, Field Hydrography and J. Galloway, Institute Electronics, held a successful operators' course on PHAS (Portable Hydrographic Acquisition System). The course ran for one week in a classroom environment, and included "hands on" experience with PHAS units coupled to depth and position simulators. D.B. Smith, Computing Services, adapted the FORTRAN HAAPS software to process PHAS data, introducing improvements at the same time.

Two new PHAS units were delivered late in the year and acceptance tests were carried out.

A summer student spent two months documenting older FOCAL programs, and implementing FORTRAN programs from the University of Victoria IBM to the Institute UNIVAC computer.

Installation of the Kongsberg flatbed plotting system, which was delivered in the spring, was delayed until late September, after the move to the new Institute. J. Larkin, as a member of the implementation committee, attended an operators' course at Bedford, Massachussetts, and participated in the installation and acceptance testing.



Kongsberg flatbed automated plotting machine

Programs necessary for plotting hydrographic field sheets from automated surveys were obtained from Central Region, and with the assistance of R.L.K. Tripe, Hydrographic Development, Central Region, were implemented on the Institute Computer. By yearend, the plotter was fully operational, and eight field sheets from Western Arctic, Caamano Sound, and Vancouver Harbour had been plotted.

J. Larkin attended the annual joint meeting of the American Congress on Surveying and Mapping, and the American Society of Photogrammetry in Washington, D.C.

CHART CONSTRUCTION SECTION

F.R. Smithers - Regional Chart Superintendent

R. Bell - Supervisor Chart Construction
*K. Bennett
P. Browning
G. Chan
D. Clark
*E. Coulter - Supervisor Chart Correction
W.S. Crowther - Production Chief
D. Dobson
E. Earl
M. Farmer
D. Fisher - Supervisor Chart Sales
M. Hohl
K. Holman - Supervisor Chart Revision
*R. Johnson
K. Josephson
R. Korhonen
D. Kynoch
A. Lyon
W. Lyons
P. Morton
*C. Nast
G. Neilson
R. Parker
M. Patton
A. Philp
L. Pickell
R. Pierce
A. Ross
N. Said
R. Taylor
M. Taylor
L. Thompson
B. Watt

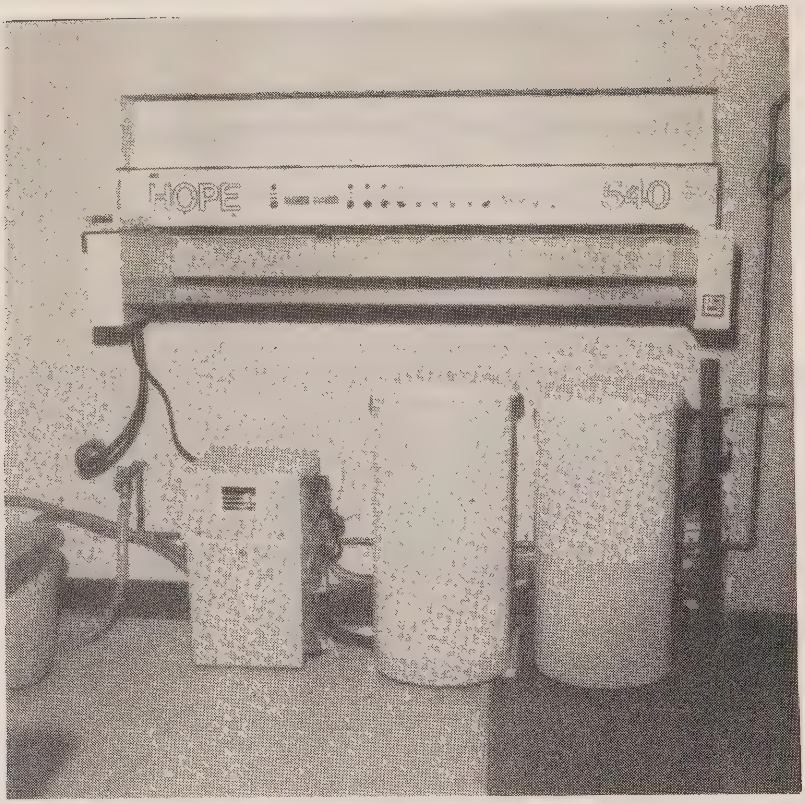
*Left in 1977

For the most part Chart Constructions move to their new quarters went smoothly and there was a minimum of disruption to the staff. Some problems were experienced, however, with the reorganization of the large chart inventory and re-establishing of the photographic services.

As a result of Headquarters decentralization and the heavy work load, the Chart Construction staff was increased by four over the past year. The new position of Pacific Region Production Chief is now filled. Two junior positions were also filled and one position was filled by a transfer from the Field Hydrography Section.

Two members of the Pacific Region Chart Construction staff completed the first Cartographic Training Course held in Ottawa this past spring. The course proved to be beneficial and further West Coast participation in future courses is anticipated.

The Chart Construction photographic laboratory received a Christie Automatic Film Processor this year and its installation coincided with the move to the Institute. This equipment aids in maintaining a high standard as well as greatly reducing the turn around time for Chart Construction's reprographic materials.



"Reprodot" automatic film processor

Chart Construction, in a joint venture with Field Hydrography, purchased a Kongsberg 1216 Flatbed Plotter and delayed the installation until the time of the move to the Institute. This equipment forms the base from which the Pacific Region Chart Construction Section will "get its feet wet", in automated Chart Construction. The Kongsberg system is capable of assisting in the production of reprographic material by inking, scribing, film cutting and photo-plotting. Four members of the Pacific Region staff have received training in the operation of the system and work is underway to make Headquarters development section's drawing routines compatible with the Kongsberg system.

In the past year emphasis has continued on the production of metric charts for the Juan de Fuca Strait and approaches to Vancouver Harbour. This region currently has seven charts under construction with an additional three to be started to complete this series. Two Loran-C small scale charts are in hand to provide coverage for deep draught vessel traffic off the west coast of Vancouver Island and an additional five charts complete the present work load.

The statistics for the past year give some indication of the work produced:

New Editions processed[a]	55
Reprints processed[a]	9
New Charts processed[a]	6
Notice to Mariners processed	64
Chart Corrections made	1,572,975
Charts Distributed	175,938
Chart Dealers Inspected	22
Chart Dealers established	13
Chart Dealers Withdrawn	4
MAREPS Processed[b]	426

a Includes compilation, draughting and printing.

b MAREPS - Marine Reporting Systems established in cooperation with Canadian Power Squadrons.

Chart Construction

TIDAL AND CURRENT SURVEY SECTION

W.J. Rapatz - Acting Regional Tidal Superintendent

A.B. Ages - i/c Hydraulic Research
R.E. Brown
C.C. Carracedo
W.R. Crawford - i/c Tidal Research
A.N. Douglas (Computing Services)
W.J. Harris
F.V. Hermiston
*D.E. Hilder
W.S. Huggett - i/c Current Surveys
A.C. Ma
J.J. Manson
A.J.R. Smedley
F.E. Stephenson - i/c Tidal Survey
M.J. Woodward
A.L. Woollard (Computing Services)

* Left in 1977

The Tidal and Current Section conducted surveys on the British Columbia coast and in the western Arctic.

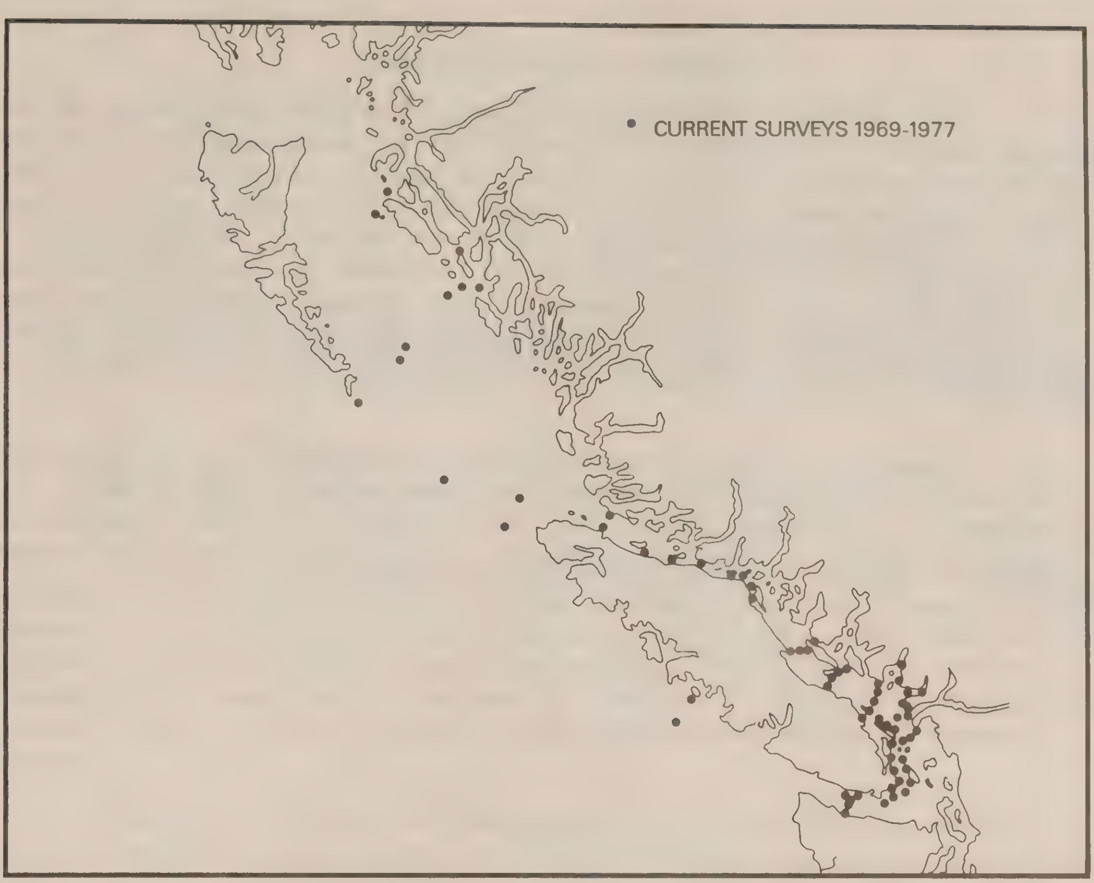
A major field program investigating the oceanography of Johnstone Strait was carried out in cooperation with the Offshore Oceanography Section. A major tidal and current survey was carried out in Queen Charlotte Sound and Caamano Sound where 3 tide gauges and 19 current meters were deployed for a period of several months. This survey was carried out to collect necessary data to advise on the route large tankers would follow on approaching the British Columbia coast, and to assist mathematical modellers in constructing a model of Queen Charlotte Sound and Hecate Strait.

At the request of the Ministry of Transport, a current survey was carried out at the entrance to Eskimo Lakes in the western Arctic. The Ministry of Transport ship *Nahidik* was used for this purpose for a period of 6 days.

Preliminary pages of a proposed current atlas of Juan de Fuca Strait and the Gulf Islands were constructed and distributed to major users to elicit comments and suggestions.

Several temporary tide gauges were operated in support of hydrographic field parties. A gauging station was constructed at Kitimat in support of the oilport inquiry. Aanderaa tide gauges, which were deployed last year at several permanent gauging stations in the Arctic, were recovered, and the records processed. Records from 24 permanent and 6 temporary stations were processed, digitized and the data sent to Marine Environmental Data Service. A completely new digitizing system for these analogue gauging stations was implemented which has enabled us to reduce significantly the time required for processing and to improve the accuracy of tidal data.

A field survey of tidal currents, salinities and temperatures in the main arm of the Fraser River was intensified and extended to other parts of the delta. This project was undertaken by the hydraulic research



Locations of current surveys conducted by
Tidal and Current Survey Section from 1969 to 1977

unit to provide an existing numerical model with additional parameters and hence improve its predictions of vertical as well as horizontal tides. Observations were made jointly with Water Quality Branch of Inland Waters Directorate. Production runs of the numerical model of the Fraser were continued for government agencies and engineering firms.

The design of a previously developed oil-spill tracking device was modified and adapted for airborne surveillance. Using a variety of oil spill simulators, a number of drift experiments were carried out in the Strait of Juan de Fuca to examine the surface movement and the possible path of a future spill in that area. The hydraulic research unit also participated in the West Coast Oil Port Comparative Study, by compiling the available oceanographic data in B.C. waters and designing a variety of oil spill scenarios.

Analysis of approximately 80 time series of current measurements made by our section and by U.S. National Ocean Survey was carried out, using a newly developed method to find time and rate comparisons between sets of observations. Four secondary current stations were added to Vol. 5 of the Canadian Tide and Current tables.

The records retrieved in 1975 and 1976 from tide gauges on Union, Bowie and Surveyor Seamounts in the North Pacific were analyzed, and tidal charts of the eastern portions of the North Pacific were prepared. These are the first deep sea tidal records obtained off the west coast of Canada, and will aid oceanographic research within the 200 mile fishing limit. These charts are part of the Canadian contribution toward an international program to map the tides in the central basins of the oceans. Research was begun on the effect of atmospheric pressure changes upon sea levels and currents in the North Pacific by examining the long period signals observed in these records.

A spectral analysis program has been tested on short term tidal records (less than 1 year) to improve the resolution of the harmonic constituents. The response method of tidal analysis has been adapted to the Institute of Ocean Sciences computer, and is being used on the seamount records.

TSUNAMI ADVISOR

S.O. Wigen

S. Wigen returned December 1st, 1977 from a posting of more than 2 years with UNESCO as Associate Director of the International Tsunami Information Center in Honolulu. He worked there under Canadian funding, and was concerned with mitigating the effects of tsunamis throughout the Pacific. He visited Indonesia and Australia after the destructive tsunami of August 19th.

Mr. Wigen is presently on a special assignment coordinating a historical study of tsunamis to provide a better data base for tsunami research and warning systems.

COMPUTING SERVICES SECTION

K. Teng - Head

R.E. Johns
D.B. Smith
J.W. Butcher
A.N. Douglas - Tides and Currents
M.G. Foreman - Numerical Modelling
J.S. Page - Ocean Chemistry
P.J. Richards - Nuermical Modelling
+M.E. Woodward - F.S.R.G.
A.L. Woollard - Tides and Currents
*R. Dykes - Management Services
+S.J. Szalai - Management Services
E. Wong - Offshore Oceanography

+ Joined in 1977
* Left in 1977

1977 was a busy year for Computing Centre personnel involved in development of the Univac 1106 computer system at the Institute of Ocean Sciences. Conversion of all Ocean and Aquatic Science users from outside services (University of British Columbia (UBC) and University of Victoria) was essentially completed by the end of March. Dr. Crean's numerical model of Georgia Strait is now the only large application using an external computer.

Several additions and enhancements to the software available on the Univac system include a new level of the Operating System featuring remote console support enabling a user to make direct enquiries to the system, new versions of language compilers, new versions of the Editor, Sort/Merge and implementation of the NYU news processor to provide timely information to users, and implementation of additional applications software such as: Calcomp plotting routines with Tektronix preview capability (February), Univac Math/Stat package, UCLA BMD statistical programs, and selected routines from the UBC sub-routine library.

The system 2000 Database Management System was used in the implementation of several applications, including an Inventory Management System and library book catalogue for the Institute, a fish health inventory for the Pacific Biological Station, and a Fraser River Inventory and Herring Spawning information for Fisheries Management.

The Central Processing Unit (CPU) and memory were upgraded in April effectively doubling user memory and reducing swapping of programs, thereby improving response time and throughput. It also enabled implementation of a PL/I compiler and system performance measurement aids.

A Uniservo 16 magnetic tape sub-system was added, an EBCDIC - Field data hardware translator was included to facilitate the conversion of IBM (EBCDIC) tapes produced elsewhere, and 4 low speed communications ports were added, bringing the total to 10 for dialup access. A positive power-disconnect switch was installed in April to disable the system in event of a power interruption, since serious power problems in January resulted in some hardware damage with consequent down-time.

In April, operator hours were extended to 12 hours (0800-2000 hrs) and the system was left on (in unattended mode) during week-day evenings to enable access for time-sharing users. Preventive maintenance time was gradually reduced, being replaced at year's end by running on-line diagnostic routines. The average system availability during scheduled hours despite power problems and interruptions was about 90% and by December 71% of batch jobs were turned-around in 10 minutes or less. A Computing Centre Information Service (telephone 656-8333) was established in June manned by Computing Services staff on a rotation basis to answer questions about use of the system and to provide some debugging guidance.

The charging algorithm was established and charge-back to users was implemented, effective 18 April 1977. The first month-end reports were distributed in July and the first accounting statements and invoices for non-OAS users were available in October. The rate structure was designed to be competitive with external service bureaus. The latest set of benchmark comparisons indicated that the average cost of runs performed on the Univac was approximately 75% of the University of British Columbia commercial rates.

The average monthly usage (from April) during 1977 was:

OAS users	$18,853
Other users	5,054
Total (all users)	$23,907

This approximately equals the monthly operating cost of the Univac 1106.

Computing Services personnel have been directly and indirectly involved in numerous projects with the other groups now on site at the Institute. The use of PHAS data acquisition systems by Hydrography required the development of interface routines for Hewlett-Packard and PDP-8 computers as well as a PDP-8 Fortran IV package for in-field processing of survey data. This package is based on the old HAAPS processing system with added features for dealing with large-scale surveys such as Vancouver Harbour. The Sykes 9250 floppy disk (acquired in March) proved its worth in this development effort. Local plotting of Hydrographic field sheets on the new Kongsberg flatbed plotter is now possible, using plot tapes generated on the UNIVAC system with programs adapted from Central Region.

Various new devices were interfaced to the minicomputers. Arctic Marine Science has connected a Guildline Digital CTD recorder to the Hewlett-Packard 2116 disk operating system. Tides and Currents implemented a similar link from their HP-9825 calculator-based digitizer to the HP 2100. Coastal Zone applied a multiple digital-to-analog converter (MULTIDAC) interface, designed by Institute Electronics, to produce graphic output on an X-Y recorder. Data logging capability for the Current Shear Probe was provided by extending Offshore Oceanography's CTD acquisition system. A transcription program for Offshore's Geodyne current meter data cartridges was started late in the year, with an interface designed by Institute Electronics.

The micro-computer is also here to stay. Software development is in progress for a micro-processor based data logger being built jointly by the Ocean Mixing and Institute Electronics Sections.

INSTITUTE ELECTRONICS

J.V. Watt - Head

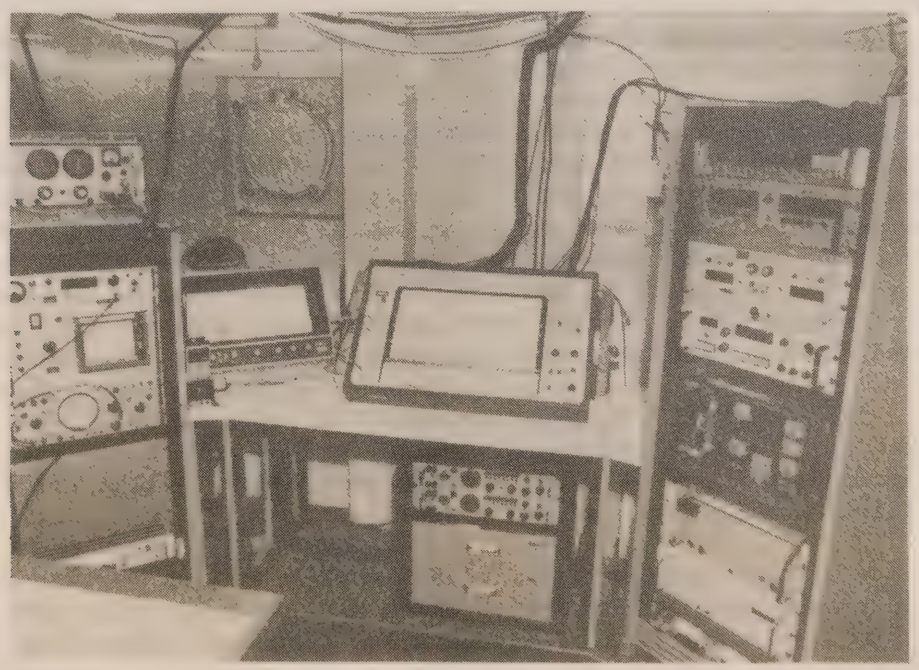
R.A. Cooke - (with FSRG)
T.A. Curran - Project Engineer
L.W. Dorosh
J.L. Galloway - Project Engineer
D.G. Gregson
E.W. Hinds
*B.A. Johnson
R. Loschiavo
R.A. Muse
M. Osborne
**C.F. Ryan
T.J. Soutar
W.R. Taylor - Head, Technical Support Group

* joined during 1977
** left during 1977

The major event of 1977 involving the section was the move to the new institute facilities which are already proving their worth in easing the complications involved in the provision of electronics support. Following this move, in keeping with expanding role of the section, Survey Electronics was renamed Institute Electronics. The section continues to provide electronics engineering and technical support to the Institute of Ocean Sciences.

Engineering Support

The engineering staff were very active during 1977 providing continued support of the Portable Hydrographic Acquisition System (PHAS), development of specifications and an implementation plan for a flatbed draughting system to address Institute-wide needs and completion of a number of oceanographic instrumentation projects.



Data acquisition station. PHAS (center at right)

Courses prepared and presented in support of the PHAS included an operations course for hydrographers and a maintenance course for service technologists, the latter being attended by personnel from Central and Eastern regions. Further activities involving PHAS included software modifications which permitted the recording of magnetometer data in conjunction with hydrographic information and the revision of specifications for a contract which was let for the manufacture of three new units (one for Energy Mines and Resources, Geological Survey).

Continued engineering support to assist the oceanographic sector involved the completion of a computer compatible interface for a Gould, six-channel chart recorder and of a local contract for the construction of a number of Aanderaa data tape readers. Major projects undertaken during 1977 included the development and field testing of a current shear probe system which utilized an ultra-sonic current meter head, the start of the development of a high speed, high resolution microcomputer controlled 64 channel data acquisition system for the submersible *Pisces IV* and a plug-in depth digitizer for the PHAS.

Technical Support

The Technical Support Group provided field support for the Caamano Sound, Vancouver Harbour, MacKenzie River and the Amundsen Gulf surveys. The Arctic program was greatly assisted by on site modifications to the PHAS software. In preparation for this 1977 Arctic cruise a major equipment installation was successfully carried out on *Pandora II* during the two weeks prior to her departure. Among the equipment installed were Decca, Lambda receivers, Range Positioning System, Loran C, satellite navigator system, gyro compass, Collins SSB radiotelephone, inter-com, facsimile receiver, and a complete hydrographic acquisition station. Significant effort was expended prior to the 1977 field season to make all sounders, depth digitizers, pattern digitizers and microwave positioning systems compatible with the input and output requirements of PHAS. These modifications included PHAS controllable fix mark circuits on the Ross, Atlas, and EPC recorders in addition to the conversion of the output format of all of these digital data instruments. Further work was performed to couple an Innerspace model 412 digitizer to a Ross Sounder.

The Loran "C" calibration exercise begun in 1976, was ably supported and involved shipboard, helicopter and mobile lab equipment installations, cruises on both *Parizeau* and *Vector*, helicopter flights and trips into the B.C. interior and north-west U.S.A.

1977 also marked the initiation of a program for the installation of an Institute radio base station which shall consist of a 1KW transmitter and log periodic beam antenna covering the frequency range from 6 to 30 MHZ and a locally controlled receiving and low powered transmitting station.

OPERATIONAL SUPPORT SERVICES

J.V. Watt - Head

J. Steeples - Head ,Mechanical Support Section
*** A.E. Moody

*** Transferred from F.S.R.G.

To accomodate a growing need for mechanical design, construction and testing services in the region,two shops, one for mechanical design and another for fabrication and mechanical testing, were incorporated in the design of the Institute. The responsibility for these facilities was assigned to a new section, Operational Support Services.

Mechanical Support

The mechanical support section started during 1977. The section provides mechanical design, instrument making, machining and fabrication services in addition to facilities management. The section also is to provide mechanical expertise in preparing specifications and initiating and supervising contracts let to local industry related to this area of endeavour.

The mechanical design shop is equipped as a precision machine and instrument making shop and shall, by early 1978, have a mechanical drawing office. The major equipment available includes two precision lathes, one mill and a variety of drill presses, grinders and saws.

The fabrication and mechanical test shop is equipped with welding, sheetmetal, woodworking and grinding facilities as well as a cleaning tank, bead blast and a paint booth.

INDUSTRIAL LIAISON

G.R. Smith - Industrial Liaison Officer

The level of expenditure on science related contracts has increased steadily each year since the introduction of the Make-or-Buy policy, and continued to do so in 1977/78. The Institute is now spending greater than 50 percent of the operations and maintenance budget available for oceanography in support of contracting.

This total is unlikely to increase unless there are increases in overall funding. As a result, other government sources of funding such as unsolicited proposals are becoming increasingly important as a means of stimulating contract activity and much of the increase in 1977/78 was due to these funds. Until economic restraints are lifted, a major objective is to maintain the present level of contracting and, where possible, find other sources of funding.

It is probably too early to identify results of contracting policy, but a few significant things have happened during 1977/78. Several companies have decreased their dependence on government contracts and are obtaining a greater number of industrial contracts. This is at least partially due to improved capability and experience derived from government contracts. Also the commercial market for science related activities appears to be expanding as a result of an increased awareness of the importance of oceanography in both environmental and engineering studies. We hope this is the start of a continuing trend.

OCEANOGRAPHIC DIVISIONS

P.W. Nasmyth - Regional Oceanographer

S. McKenzie

As part of an internal reorganization following the retirement of the former Deputy Director-General, and discontinuation of his position, the position of Regional Oceanographer was created to provide central focus and management for the oceanographic research programmes in Chemistry, Physics and Biology and to encourage inter-sectional and interdisciplinary cooperation. Consolidation of all components of Ocean & Aquatic Sciences, Pacific Region in the new Institute building at Patricia Bay brings the various groups into closer contact with each other and should further stimulate the exchange of ideas and facilitate the development of a coherent and efficient programme.

Continued erosion of available resources by almost universal cost increases, X-Budget cuts and inevitable expenses involved in relocating into the new building, has demanded very careful planning and a very lean programme in 1977. It has, however, been an active and productive year, with a number of programmes (particularly in the Arctic) assisted by infusions of funds and logistic support from outside agencies including the Environmental Protection Service and Atmospheric Environment Service of the Department of Fisheries and the Environment, the Department of Indian and Northern Affairs and several commercial organizations. In spite of financial pressures it has been possible to supplement our internal programme and maintain our Make-or-Buy support of research and development in Canadian industry at about the same level as in 1976. If present trends continue, however, increases in costs will almost certainly lead to a reduction of funds available for contracting in the oceanographic programmes in 1978.

Oceanographic work in support of environmental impact assessments has taken an even larger proportion of the total programmed effort than in the past few years, with the Canadian Arctic Archipelago and the northern coastal waters of British Columbia receiving priority attention. Preparation for Canadian oceanographic participation in the First GARP Global Experiment, with successful trials of the Institute of Ocean Sciences/Hermes drifting buoy, has been a prominent Canadian feature in the international scene, as active involvement in the experiment approaches in mid-1978.

The infrastructure of the oceanographic programme remains as in past years. Detailed reports from each section follow.

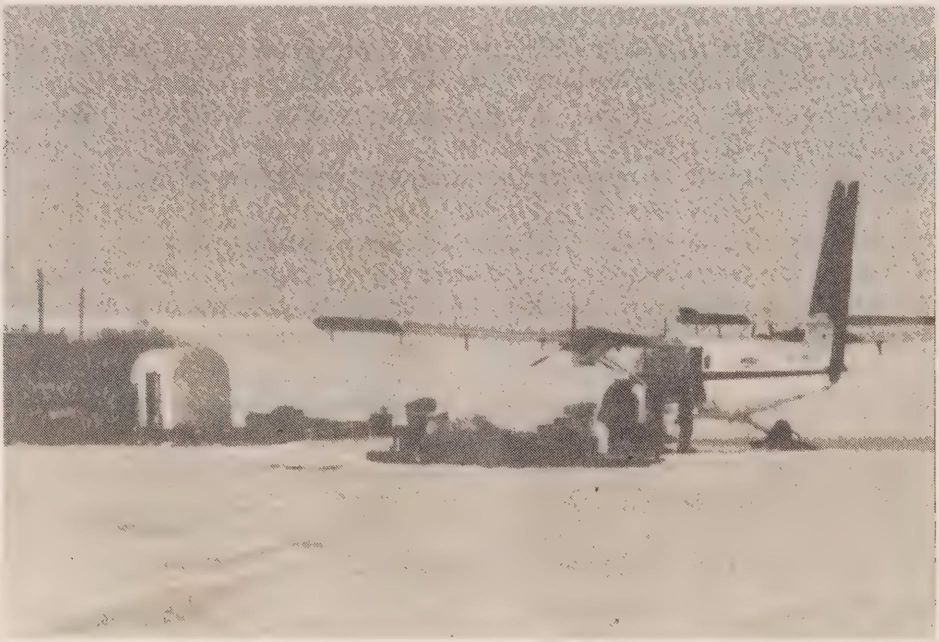
FROZEN SEA RESEARCH GROUP

E.L. Lewis - Head

*J.W. Butcher - Computing Services
R.A. Cooke - Institute Electronics
A.W. Koppel
R.A. Lake
J.M. McNeill
*A.E. Moody
S.W. Moorhouse
R.G. Perkin
D.L. Richards
*E.E. Richards
R.B. Sudar
D.R. Topham
E.R. Walker
+M.E. Woodward - Computing Services
P.E. Greisman - Postdoctoral Fellow

+ Joined in 1977
* Left in 1977

The Frozen Sea Research Group was established in 1964 to study oceanographic problems unique to ice covered waters and their research efforts have been concentrated in the Canadian Arctic. Much of their expertise in the scientific understanding of oceanographic processes in Arctic waters is now being directly applied to the problems associated with the exploration and exploitation of resources in the far north. The projects undertaken in 1977 are summarized below.



Assembling equipment on the sea ice prior to deploying current meters in Crozier Strait, April 1977

Water Movement in Channels of the Arctic Archipelago

In March 1977 an effort was made to retrieve ten current meters laid in 1976 across the bottom of Byam and Austin Channels between Melville and Bathurst Islands at about 75° north. It was a frustrating trip, as ice had carried away nine of the meters! It was indeed fortunate that the greater part of two months data had been obtained from the meters from our acoustic/radio telemetering and recording system before their destruction. After recovering one meter the tracked vehicle party crossed Bathurst Island via Polar Bear Pass to lay an array of 21 current meters across Crozier Strait between Bathurst and Cornwallis Islands. Meters were placed in the top and bottom boundary layers to obtain information on likely oil movement just under the ice, and about forces acting upon a bottom-laid pipeline. Meters were also positioned at mid-depth to allow calculations of water transport. The movement of pollutants from a hypothetical oil well blowout in the Arctic Islands is largely unknown and our studies are an essential part of predicting consequences of such an event.

Most of these current meters were removed in June and August but two bottom meters were left down to record through the winter with recovery planned for March, 1978.

Water structure (CTD and current profiles) was measured in Austin, Crozier and Pullen Channels.

Recovery of current meter from the sea floor in Austin Channel, March 1977. The meter recorded data for one year.

Fjord Studies

These continuing studies were centered at d'Iberville Fiord on Ellesmere Island during March and April when air temperatures lingered near -45°C (-50°F) for days on end. A salinity/temperature survey of the fjord was undertaken together with a survey of several micro-constituents (silicate, phosphate, nitrate) and dissolved oxygen, deuterium and tritium. The results showed that horizontal gradients of the passive tracers were undetectable while tritium reached high values near the tide water glacier. High tritium values result from the nuclear bomb tests in the 1960's.

Since ice cover prevents wind-mixing, and run off from the land is restricted to a few months of every year, Arctic fjords are a simpler circulatory system than fjords at more temperate latitudes. Results from studies on Arctic fjords may thus be used to elucidate problems arising from coastal pollution in southern Canada, for example on the British Columbia coast.

As the sea ice grows, salt is rejected into the underlying water column producing vertical convective motion immediately below the growing interface. The dynamics of this process are of great interest in regard to the lodgement and dispersal of oil deposited at the ice/water interface by an offshore oil well blowout as well as in terms of the fundamental physics of the atmosphere/ocean energy exchange and its effect on world climate. Attempts were made to employ ultrasonic current meters interfaced with a Hewlett-Packard 9825 A desk computer to measure the small scale convective flow patterns beneath growing sea ice. The convective surface layer beneath the ice was abnormally thin in March 1977 in d'Iberville Fiord, being less than 30 cm thick. Since this thickness was roughly the same as the dimensions of the instrument head, i.e. their spatial resolution, the correlation measurements were not useful. Early analysis of the records revealed a heavy incidence of turbulence attributed to seals attracted to the open warmed hole in the six foot thick ice through which our instruments were lowered.

Analysis of data taken in Cambridge Bay in previous years was completed. These illustrated the effects of internal waves breaking on the shore on the mixing of basin waters in this small fjord - a study of direct importance to the vertical movement of pollutants in arctic coastal waters.

A brief review of results from our fjord studies was included in a report on aspects of oceanography in the archipelago published during the year.

Deep Oil Well Blowouts

Release of natural gas (methane) invariably accompanies oil escaping in a seafloor oil well blowout. At sufficiently high temperatures this escaping gas can form a hydrate of density about 0.9 gm cm^{-3}. Previous studies had considered gas driven plumes from shallow depths but formation of hydrates in deeper blowouts would completely change plume dynamics and hence movement of oil escaping. Since the kinetics of hydrate formation are poorly known and the matter is of such importance, a program to elucidate

formation of hydrates was begun by releasing gas and oil from the submersible *Pisces* at depths to 640 m. Hydrates were observed to form in profusion. Therefore contracts were let for laboratory work in which kinetics of hydrate formation are being investigated in a pressurized vertical water tunnel in which droplets of oil and gas can be suspended.

A preliminary analysis of the release of gas from a saturated oil drop originating in a blowout in its buoyant passage to the sea surface indicated that it would probably become supersaturated as the pressure reduced. Spontaneous formation of gas bubbles within the drop is thus possible which could provide energy for emulsification. This fact combined with hydrate formation would change the clean up problem entirely.

Completion of the analysis of data collected during our simulated "blowout" in Patricia Bay in 1976 using compressed air showed that large bubble plumes are not equivalent to similar rising plumes produced by heating as had been thought previously.

Instrumentation

Considerable effort has been expended over the last few years to build a sensor chain which through simultaneous measurements of temperature and electrical conductivity will yield values of water salinity. First field tests this year indicated good long-term stability of our system and we are pushing ahead with the construction of a chain and tests of long-term deployment in a fouling environment. In the meantime, preliminary plans are being made for the commercial manufacture of this important instrument.

Because the north magnetic pole is situated in the centre of the area in which we are working in the Arctic the horizontal component of the earth's magnetic field is insufficient to give adequate directional indication to our current meters. By contract we hope to acquire current meters which will allow direction determination by acoustic orientation of the meter to an acoustic source in known position. This development promises the first practical attainment of current directions near the north magnetic pole for non-rigid moorings.

Salinity

The proposal for a "Practical Salinity Scale" based upon the conductivity ratio of the sample with standard seawater at 15°C has been accepted by the UNESCO/SCOR/IAPSO/ICES "Joint panel on oceanographic tables and standards" and will be submitted to its parent bodies for ratification. Standard seawater will be defined in terms of its conductivity ratio with a KCl solution of fixed concentration by weight and the primary form of the relation $S = F(R_{15})$ will be determined from measurements made on weight diluted standard seawater. Thus all seawaters having the same R_{15} will have the same practical salinity, irrespective of ionic content. The newly proposed definition is in accord with, and is being promulgated with, a new equation of state for seawater proposed by others. Together these formulations should enable a far more precise comparison of data between institutions than has been possible in the past.

OCEAN MIXING SECTION

P.W. Nasmyth - Head

A.E. Gargett
A.R. Nowell - Postdoctoral Fellow
G.W. Chase
R.C. Teichrob

This was a year of retrenchment and catch-up in the Ocean Mixing program. The major effort was an extensive modification to the *Pisces*-borne data sensing and recording system, for improved performance and reliability, lower noise levels and reduced cross-talk between channels. A continuing low level of effort has been put into the further analysis of old (pre-*Pisces*) data and extensive work has been done on performance characteristics of and calibration techniques for the Siddon-Osborn "shear probe" now used on *Pisces* for the two cross components of turbulent velocity fluctuations.

The re-built system, including a new data acquisition sub-system built around two micro-processors and using dual digital cassette units, will be ready for trials in early 1978.

Dr. Gargett has been on sabbatical at Woods Hole for the year, primarily to complete analysis of data from the joint Woods Hole/University of British Columbia/Institute of Ocean Sciences cruise in the Atlantic in 1975.

COASTAL ZONE OCEANOGRAPHY

D.M. Farmer - Head

W.H. Bell	J.H. Meikle
R.H. Bigham	D. Nof - Postdoctoral Fellow
H.J. Freeland*	D.G. Sieberg
L. Giovando	L.A. Spearing
G. Kamitakahara	J.A. Stickland
A.P. Lee	D.J. Stucchi

* Joined in 1977

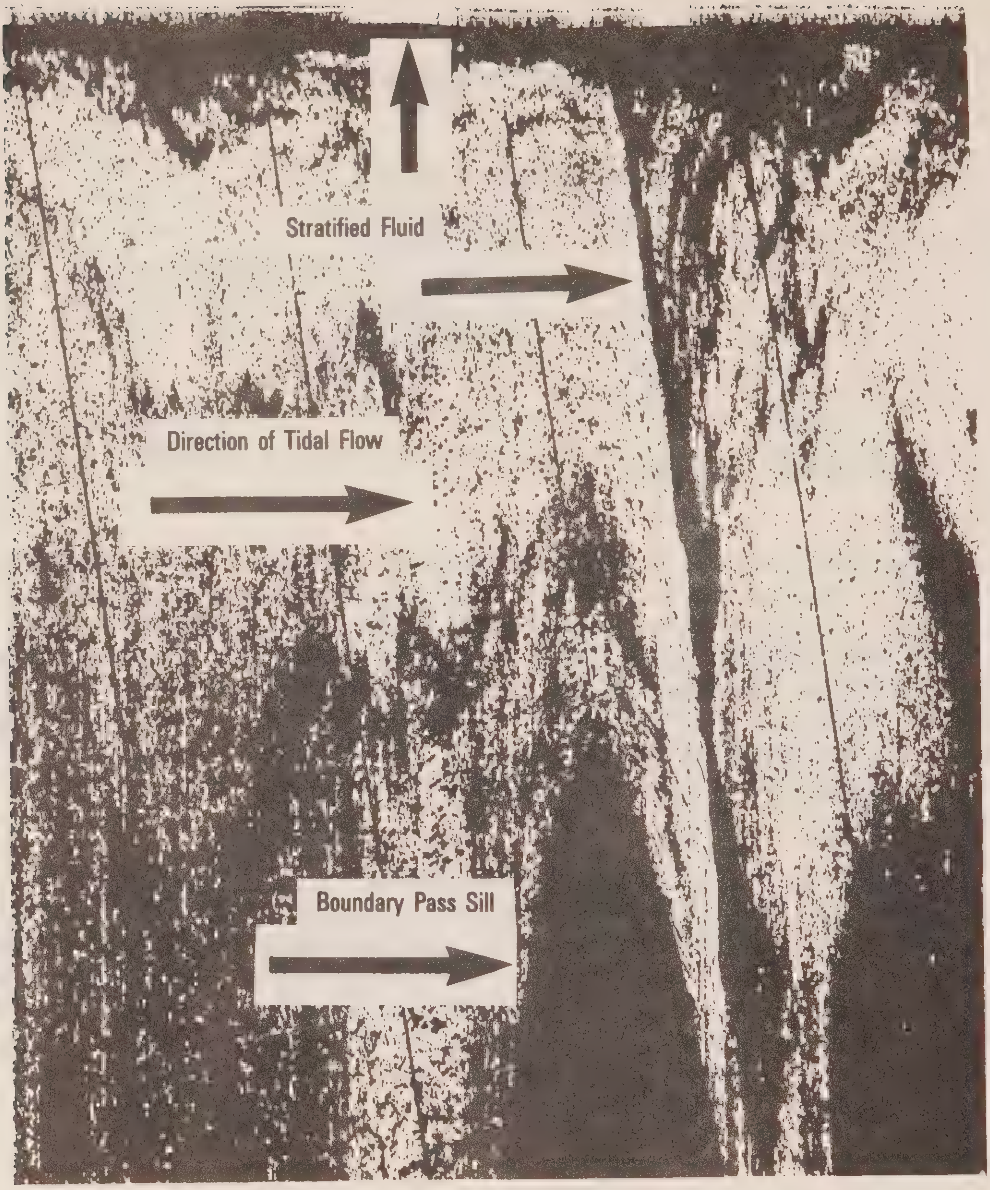
This year Coastal Zone continued and extended studies of physical processes in British Columbia Inlets. Our major program involved the study of Knight Inlet, with particular emphasis on the interaction of tidal flow with the sill and consequent effects on the circulation. This study has in turn provided new insights which have application to other areas, including the complexity of channels leading up to Kitimat. The Kitimat approaches are the focus of another study, undertaken by contract and motivated by concern over hazards associated with possible oil-port development.

Ongoing work includes the analysis of data collected in past projects (Rupert-Holberg, Haro Strait), development of mooring techniques, work on new instrumentation and software and projects relating to ocean dumping legislation. H.J. Freeland joined the group this year and concluded earlier work begun at the University of Rhode Island, connected with the Mid-Ocean Dynamics Experiment (MODE) program and also a study of the effect of variations in the earth's orbit on climate.

Knight Inlet Study

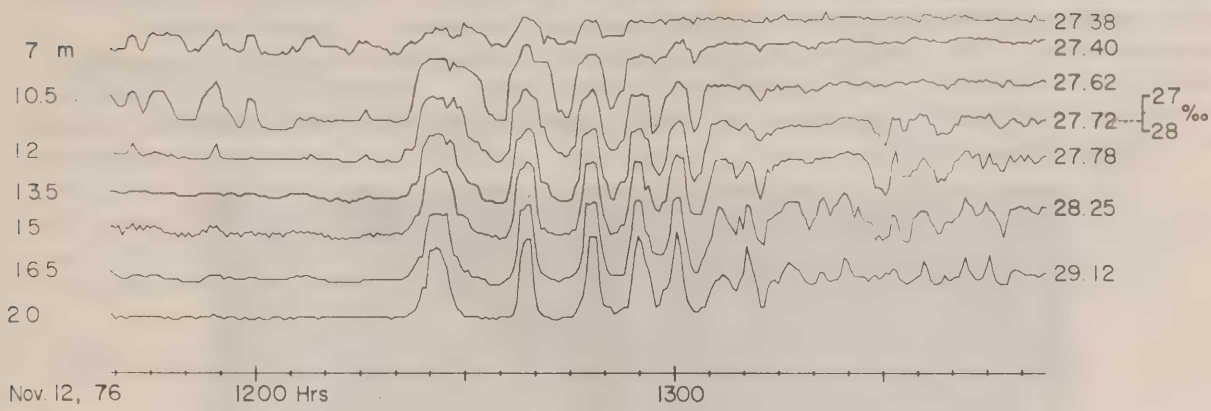
This year we began a study of the circulation of Knight Inlet. Observations included long term tide and wind measurements, a sequence of monthly temperature/salinity profiles and a detailed set of time series measurements of salinity, temperature and current velocity profiles conducted in August. For our August cruise we were joined by two ships from the University of Washington.

A remarkable result of the August cruise in Knight Inlet was the observation of an internal hydraulic transition over the shallow sill at the entrance to the inner basin. Tidally driven flow produced a critical condition over the crest of the sill which was followed by a hydraulic jump in the lee. These effects are visible on echo sounding records. The figure illustrates the dramatic plunge of surface water over the sill in Boundary Pass where similar phenomena have been observed.



Accoustic techniques are being used by Coastal Zone Section to help interpret the behavior of stratified flow over topographic features. In this example the surface stratified layer, which contains an accoustic reflector of unknown origin (possible biological matter or microstructure), is seen to plunge over the sill in Boundary Pass. The sill depth is approximately 60 m. Similar examples of internal hydraulic transitions are being studied in other areas of strong tidal forcing including Knight Inlet.

About one hour before slack water, the critical condition could no longer be sustained and the remnant of the hydraulic jump travelled downstream where it evolved into a travelling surge or undular bore. This appears to be the source of trains of internal waves which have long been observed in Knight Inlet and other inlets.



Time series plots of salinity at different depths during passage of a train of internal waves in Knight Inlet. Each plot is staggered to avoid overlap.

In our pilot study during November the waves were of large amplitude (> 10 m) and the presence of a strong wind driven shear zone which was measured with a profiling current meter suggested the utility of examining the interaction of these waves with the background flow. Observations were compared with a theoretical model for nonlinear internal waves in deep water, in the presence of a basic shear. The observed waves were approximately the same amplitude as that required to yield marginal dynamic stability, suggesting that this amplitude might constitute an upper limit; larger waves would quickly lose energy through shear flow instabilities.

Careful analysis of tidal records taken throughout the year have shown that small phase angle changes occur in the neighbourhood of the sill; moreover these phase changes may be interpreted by means of a simple model in terms of quasi-steady energy loss, and correlated with the stratification of the water. The energy loss is considerable and may have an important effect on mixing within the fjord. Estimates of the energy in the internal waves are consistent with the hypothesis that the waves constitute the main energy sink for the tides. This aspect is the focus of an additional experiment now in progress involving current measurements in the inlet.

The tide gauge data are also being used to observe small fluctuations in the sea-surface slope of the inlet. We hope to relate these changes to seasonal variations in the wind and river discharge.

Kitimat Study

An oceanographic study of the complex of channels leading up to the port of Kitimat has been undertaken. This project, which is motivated by the possibility of future oil port development, has been carried out by contract, with Coastal Zone staff providing guidance of both field work and data analysis. The project has two major thrusts; a comparison of observed and numerically modelled tidal flows and an analysis of gravitational circulation. The tidal heights and current measurements will be compared with a multi-channel one dimensional tidal model. Observed stratification is being interpreted in terms of a two-layer fjord circulation model adapted to the Kitimat channels.

Air photo of complex eddies in Knight Inlet. The eddies show up due to colour differences in the water, which depend on the concentration of suspended rock flour.

Rupert-Holberg Inlet Study

Analysis of 1975 data collected in the Rupert-Holberg system is leading to a more detailed understanding of the structure of the tidal jet. The observations allow limits to be placed on the horizontal spread of the jet, and vertical spreading is interpreted in terms of the density difference between inflowing and receiving waters and the amplitude of tidal excursion.

Saanich Inlet

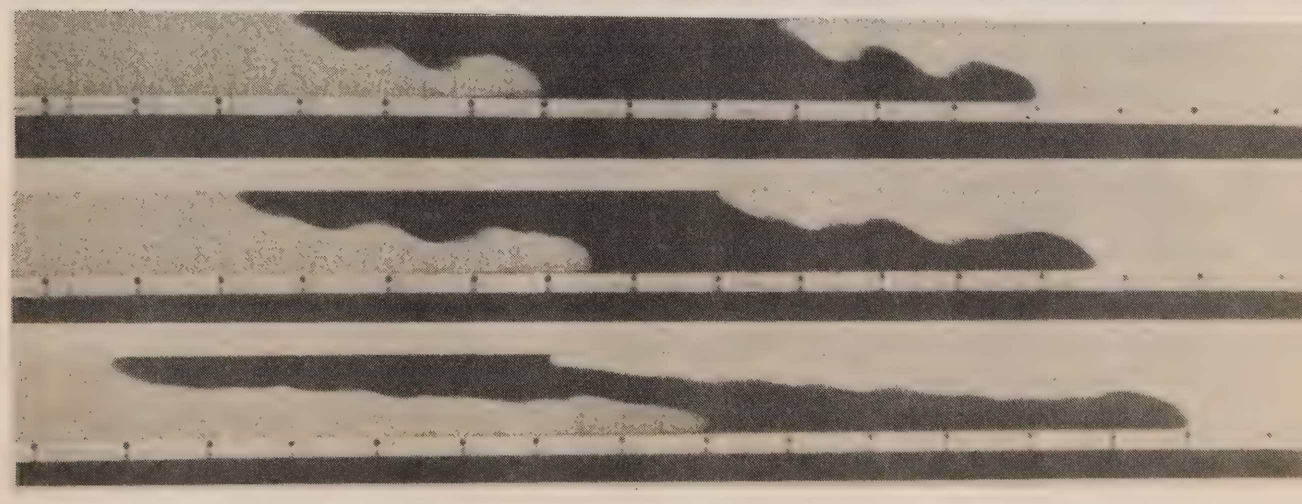
Observations of temperature, salinity and oxygen continue in Saanich Inlet as part of a long term examination of deep water exchange. This inlet which lies on the Institute's "doorstep" is a particularly convenient one to study; it is of interest in that it has a deep anoxic layer resulting from relatively poor exchange over the sill in Satellite Channel.

Lighthouse Program

While routine collection of salinity and temperature at B.C. Stations continued, two further studies of a more general nature were completed. The first of these concluded the statistical analysis and presentation of historical data from each of the stations. Another study, carried out under contract, examined the various options open for future lighthouse data collection.

Tidal Fronts - Haro Strait

Observations of tidal fronts in Haro Strait during 1975, provided the basis for a theoretical and laboratory study of the spread of mixed water in stratified surroundings together with the formation and movement of sharp density transitions. The laboratory model, which has three compartments with removable separators, the central compartment for the "mixed" water, yields a graphic display of the type of phenomena thought to occur in Haro Strait.



Mutual intrusion of fluids with various densities which leads to formation of a front. The liquid in the center (black) has an intermediate density, the one to the right (white is lighter and the one to the left (grey) is heavier. The photographs (taken at consecutive times) show the initial stages of intrusion.

Ocean Dumping

Studies of ocean dumping continued, with a further review of papers relating to dispersion of dumped material and a watching brief on developments in dumping technology. A contract was let for a study of the short-term oxygen budget of Alberni Inlet.

Mooring Techniques

Investigation of practical mooring problems relating to the flow drag of system components was continued. Drag coefficients for an extruded plastic cable fairing and for an Aanderaa thermistor chain were determined by using a mathematical mooring model in conjunction with data obtained from trial moorings. Other groups also used the model to assist them in mooring system design.

Instrument Development

Our August cruise in Knight Inlet gave us practical experience of the problems of current meter profiling. A contract was let to investigate the difficulties relating to the motion of a profiling instrument. This study emphasized the errors inherent in measuring such motion using accelerometers and gyroscopes. Further work on current-meter profiling is continuing in conjunction with Offshore Oceanography.

Task Forces

Contributions to environmental studies continued with input to a set of guidelines for the use of the B.C. coastal zone and its resources, and evaluation of a National Harbours Board proposal to expand the Roberts Bank facility.

OFFSHORE OCEANOGRAPHY SECTION

J.F. Garrett - Head

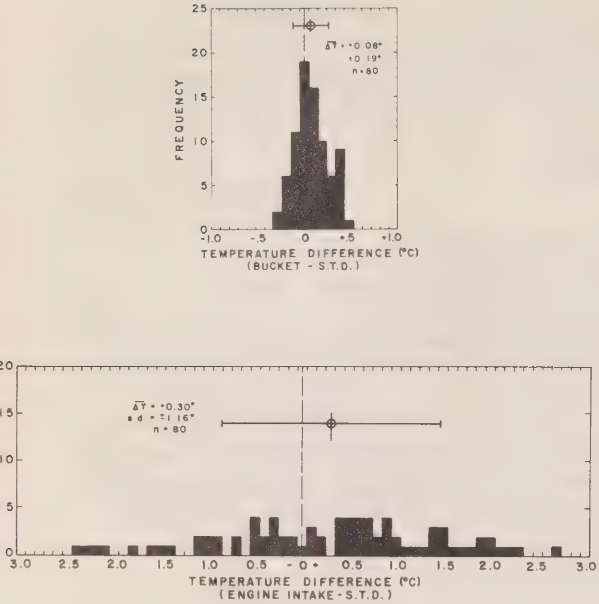
C. de Jong	B.G. Minkley
P. Kimber	M. Miyake
L. Kuwahara	S. Tabata
J. Linguanti	R.E. Thomson
J. Love	

This year the efforts of the Offshore Oceanography Group have been mostly directed towards two principal problem areas, namely the large-scale interactions of atmosphere and ocean and the physical oceanography of the continental shelf north of the Strait of Georgia. This focus has not meant the exclusion of all other interests.

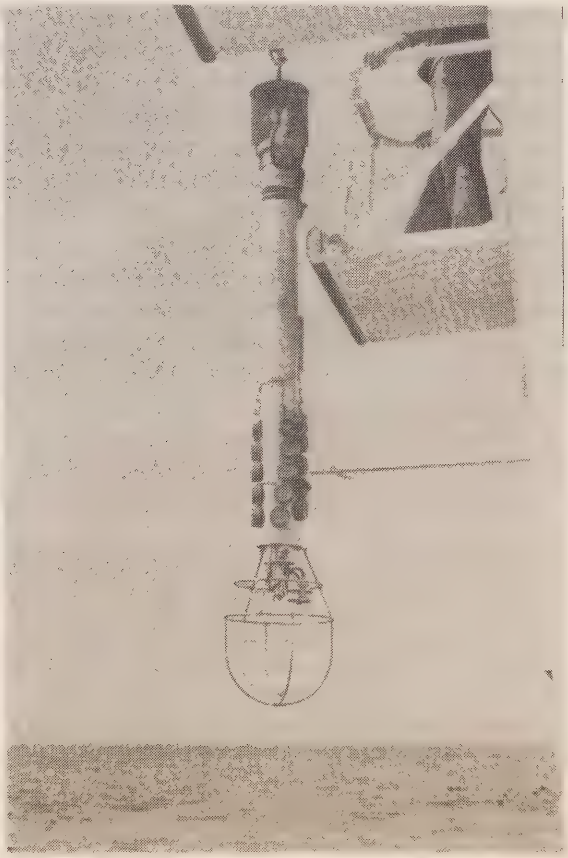
Climatology and Large Scale Air-Sea Interaction

Descriptions of ocean climate and calculations of oceanic effects on atmospheric climate based on such descriptions can be no better than observations used in compiling them. A major effort over the last year has been devoted to critically examining such data in order to prepare a realistic assessment of its accuracy. The most commonly available data is that from meteorological surface observations from merchant ships. All reports of such observations from areas near Ocean Weather Station P or one of several moored buoys were compared with the data from the weathership or from the nearby buoy. The differences show a standard deviation of 1.5°C while the data from the weathership or buoys typically show standard deviations of 0.1°C to 0.2° over a 3½ day period. This indicates the ship observations are much worse than previously expected. Different techniques of surface observations were compared on a research ship and on the weatherships. Surface temperatures from XBTs were 0.3°C higher on the average than bucket temperatures, while the standard deviations of bucket and XBT temperatures were both 0.15°C. Engine room intake temperatures, as read by the engineers, showed an offset of 0.3°C together with a standard deviation of more than 1°C. The standard deviation between temperatures at the surface and at 10 m depth decreased dramatically when surface observations were made using a reversing thermometer instead of a bucket sample. (Tabata)

A joint experiment to study the dynamics of the oceanic mixed layer (MILE) was conducted at Station P in August and September by a team from Offshore Oceanography aboard the CCGS *Quadra*, and a U.S. group with two U.S. ships. An array of current meter moorings was established and a grid of time series observations maintained. Vertical profiles of velocity, temperature, salinity and microstructure were obtained with several instruments including a profiling acoustic current meter developed at the Institute of Ocean Sciences. Although only a preliminary interpretation is available, the data shows a much larger horizontal variability than expected. (Miyake)



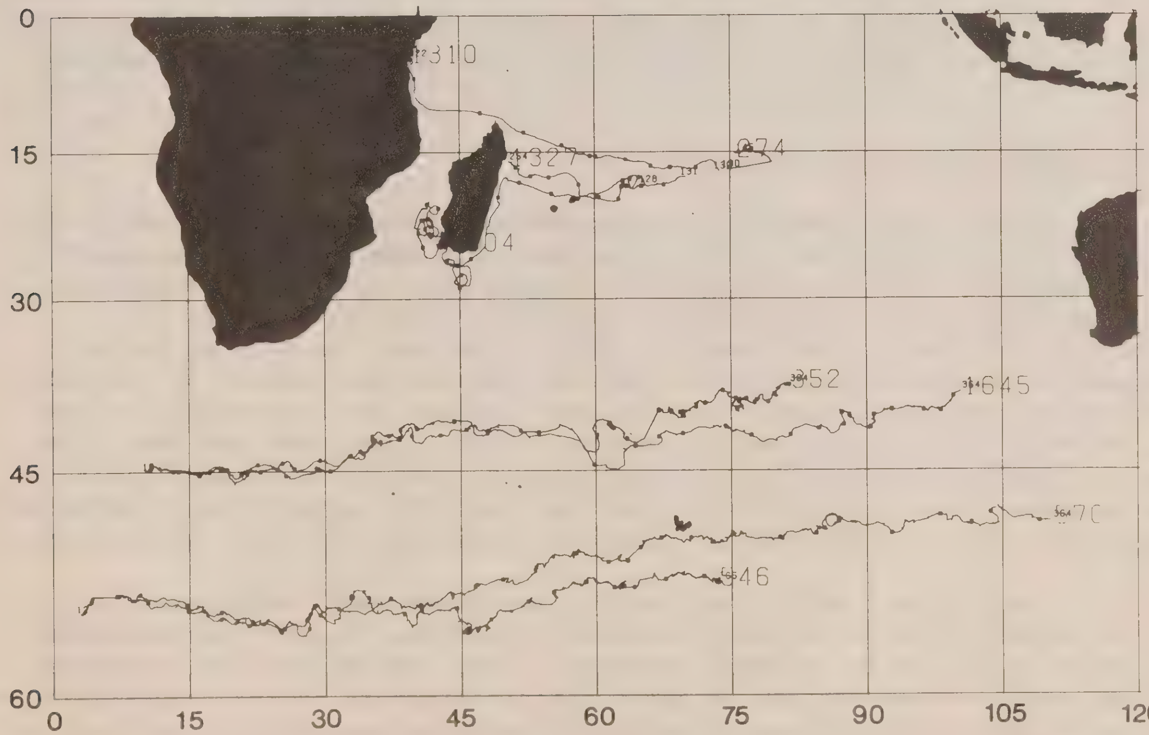
Differences between observed sea surface temperatures by bucket observation by oceanographers and reference temperatures by CTD (top) and between engine intake observations by engine-room crew and CTD reference (bottom). The engine intake temperatures are characterized by the presence of much scatter (standard deviation of ±1.2°C). This value is an order of magnitude greater than for data obtained by other methods.



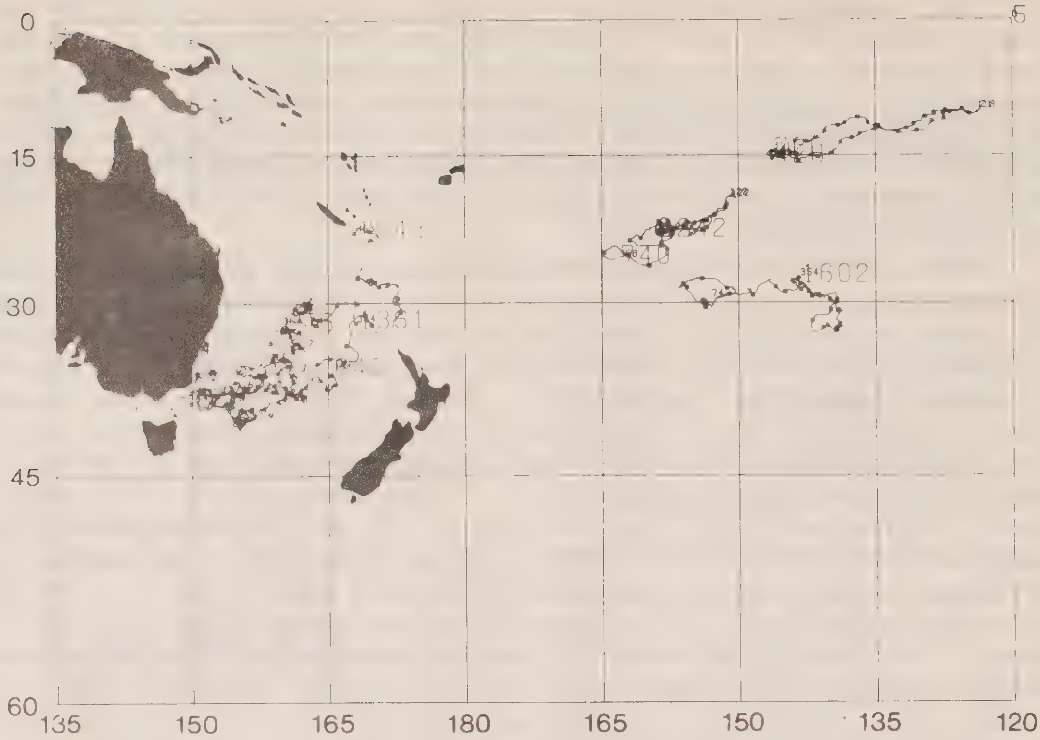
Profiling instrument developed at the Institute of Ocean Sciences being deployed from *CCGS Quadra* at Ocean Weather Station P. The instrument contains a 3-D acoustic current meter and sensors for temperature, conductivity and depth, as well as three axis accelerators.

On a somewhat larger time and space scale, data from an AXBT survey of an area between 47°N and 42°N and 166°W and 174°W repeated at two to three week intervals has been analyzed and displayed as part of the Anomaly Dynamics Study. The object of this international cooperative experiment is to study the changes occurring as a result of weather patterns to determine how important ocean currents are in the formation of large thermal anomalies such as are observed in the North Pacific, and which are thought to influence weather in North America. (Miyake)

Our part of the Canadian contribution to the First GARP Global Experiment (FGGE), or Global Weather Experiment, has lead to activities on an even larger space scale. These are related to the network of 300 drifting buoys planned for barometric pressure and sea surface temperature observations in the Southern Hemisphere during 1979. During 1977 20 prototype Canadian buoys were deployed at sea, 18 of them in the Southern Hemisphere, from the ships of five countries. The deployment points ranged from 11° South latitude to 55° South latitude and from 3° East longitude to 120° West longitude. By the end of 1977 an average of 220 days of observations had been obtained from each buoy, 9 were still operating and 7 had washed ashore. The buoy array to be used during the FGGE in 1979 will consist of 300 buoys from 8 countries which will be launched from the ships of at least 15 countries. The planning necessary to ensure that all parts of the ocean are adequately covered at the right time and to establish which ship will deploy which buoy, where, and when, has been another of our activities, in this case carried out by a contractor, Beak Consultants Ltd. Considerable effort from Offshore Oceanography has also gone into studies necessary to ensure that the data from the buoy array has the necessary accuracy and that the data processing produces the best possible data quality, as well as into the international management of the buoy observing system. (Garrett)



Tracks followed by prototypes of Canadian drifting buoys designed for use during the First GARP Global Experiment. The four southernmost tracks all represent drifts of almost one year.



Tracks followed by prototypes of Canadian drifting buoys designed for use during the First GARP Global Experiment. The "spaghetti" in the Tasman Sea results from the tracks of four buoys.

The programme of oceanographic observations from the weatherships at Ocean Weather Station P and along Line P was continued for yet another year.

Oceanography of the Continental Shelf

Work in the northern passages between Vancouver Island and the mainland continued with an active programme of current meter observations and a series of CTD observations at two month intervals. This programme, being carried out jointly with the Tidal Survey Section is aimed at producing a picture of the annual cycle in this area, as well as better information on the propagation of the tide through the network of channels. Preliminary results indicate that the most intense vertical mixing of the outflowing brackish layer and the deeper inflow occurs over the shoals in Race and Current Passages in Johnstone Strait, that there is negligible flow of water into secondary channels, and that the currents are predominantly semidiurnal (M2) but show large changes in amplitude and phase along channel.

An internal tide is apparently generated over "Newcastle Sill" in the western portion of Johnstone Strait, leading to deep currents which are twice as big as the surface currents. This tide appears to dissipate in only 10 km. Observations of the vertical structure of the velocity field were made using the Offshore Oceanography profiling acoustic current meter. A large number of sediment samples were taken in hopes of delineating the average current field by means of depositional features. (Thomson)

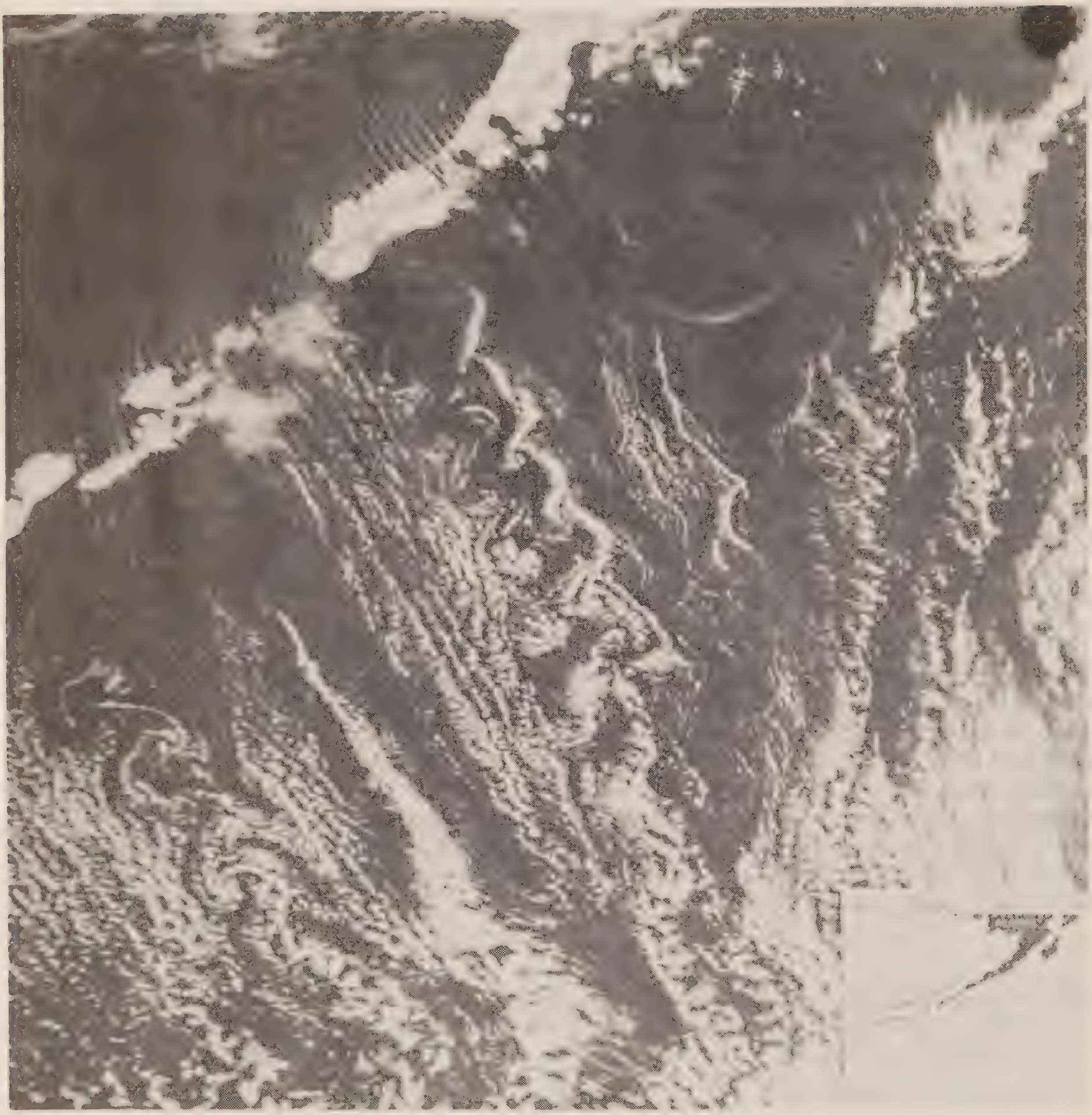
In another cooperative effort with the Tidal Survey Section current meter moorings were maintained in Queen Charlotte Sound and Hecate Strait. Wind and bottom pressure measurements were also included in this survey, which formed part of a study of currents in navigable waters leading to Kitimat, the possible site of a future oil port. Grids of CTD profiles and bottle casts were also made on 3 occasions, including two time series of CTDs in the deep channels cutting across Queen Charlotte Sound from the Pacific Ocean. (Thomson)

One result of a series of dives on the Continental Shelf made by the Geological Survey of Canada using the submersible *Pisces IV* was the discovery of ripples composed of volcanic sand and carbonate shell hash on the bottom in depths of 80 m to 105 m. Typical wavelengths for such ripples were 30-100 cm with heights of 15 to 30 cm, with the crests running nearly parallel to the coastline. These could result from the water velocities associated with long swells with periods of 12-14 seconds and heights of 4.5 to 9.0 metres arriving from the open Pacific to the southwest. The wave records from the waverider buoy near Tofino show that waves of the right period and height do occur in the area. (Thomson)

Vortex Streets in the Wake of the Aleutian Islands

The characteristics of a series of cloud-delineated wake patterns downwind of isolated mountain barriers on the Alaskan Peninsula and eastern Aleutian Islands were studied using a geometrically corrected NOAA satellite picture in conjunction with available meteorological information. Four of these wakes were shown to be atmospheric analogues of Karman-type vortex streets observed in laboratory experiments. A critical Reynolds number of 92 ± 5 was estimated for the flow, while the drag coefficients associated with the vortex streets ranged from 1.1 for an irregular, asymmetrical wake to 2.3 for a regular symmetrical wake. The turbulent eddy viscosity ranged from 1.2-1.8 x $10^3 m^2 s^{-1}$. (Thomson)

Note: See page 40 for NOAA satellite image of vortex streets in the wake of the Aleutian Islands.



NOAA satellite image of vortex streets in the wake of Aleutian Islands. Vorticies are formed downstream of larger mountain peaks in a layer of stratocumulus clouds lying below 500-1000 m elevation provided the Reynolds number of the flow exceeds a certain critical value.

NUMERICAL MODELLING

R.W. Stewart - Head

P.B. Crean
R.F. Henry
P.J. Richards - Computing Services
T.S. Murty (seconded from H.Q.)
M.G. Foreman - Computing Services

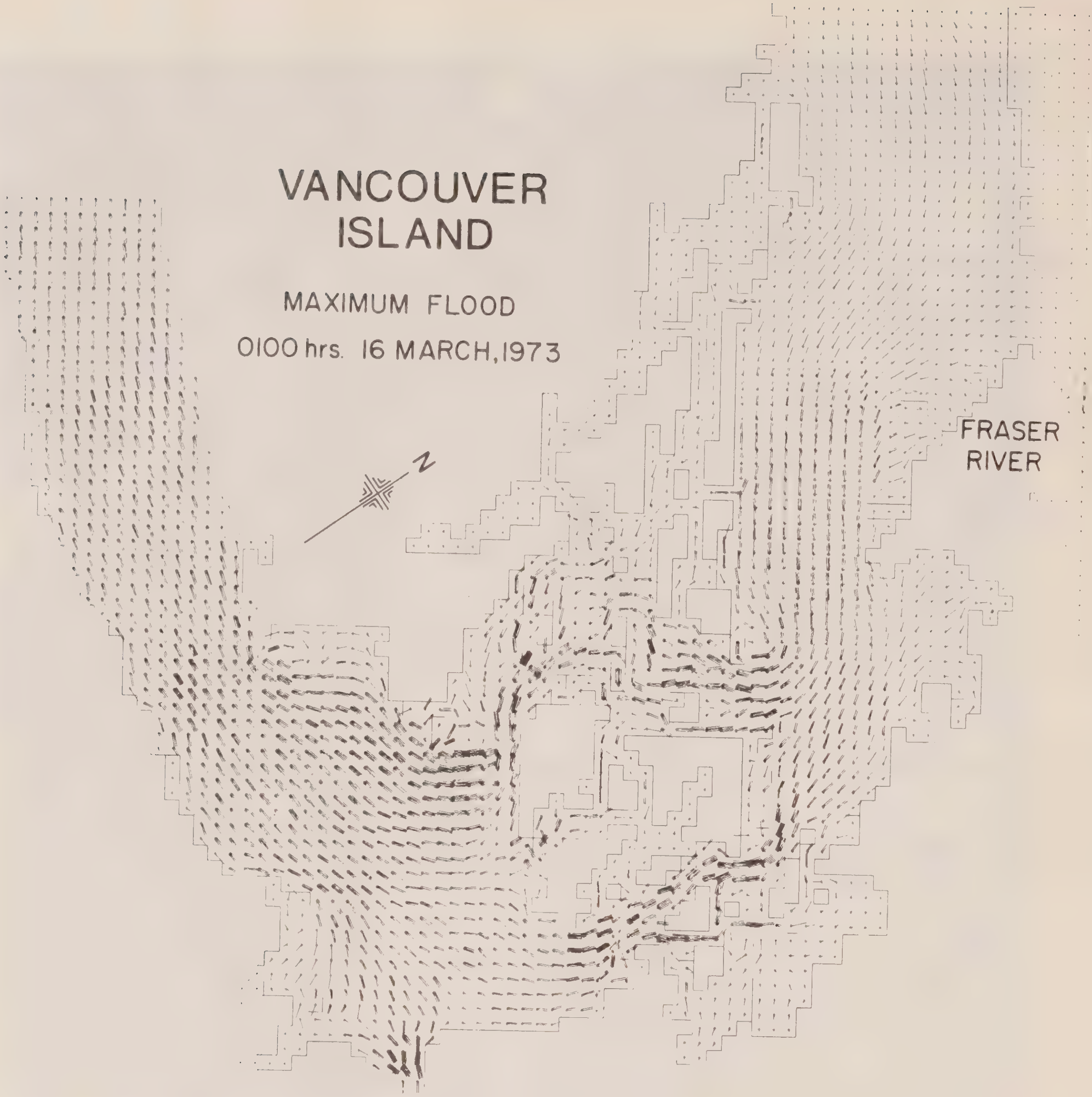
The Section continues to be involved in the development and application of numerical models for simulation of oceanographic conditions in areas of high priority.

Tides in the Queen Charlotte Sound - Hecate Strait - Dixon Entrance system have been simulated successfully using a linearized model. A technique simpler than Proudman's indirect method (proposed in 1925) has been developed to utilize available tidal observations. The results of the model will be summarized in the form of cotidal charts for the whole system.

An ocean circulation model is being developed to study enhancement of barotropic circulation by baroclinic effects.

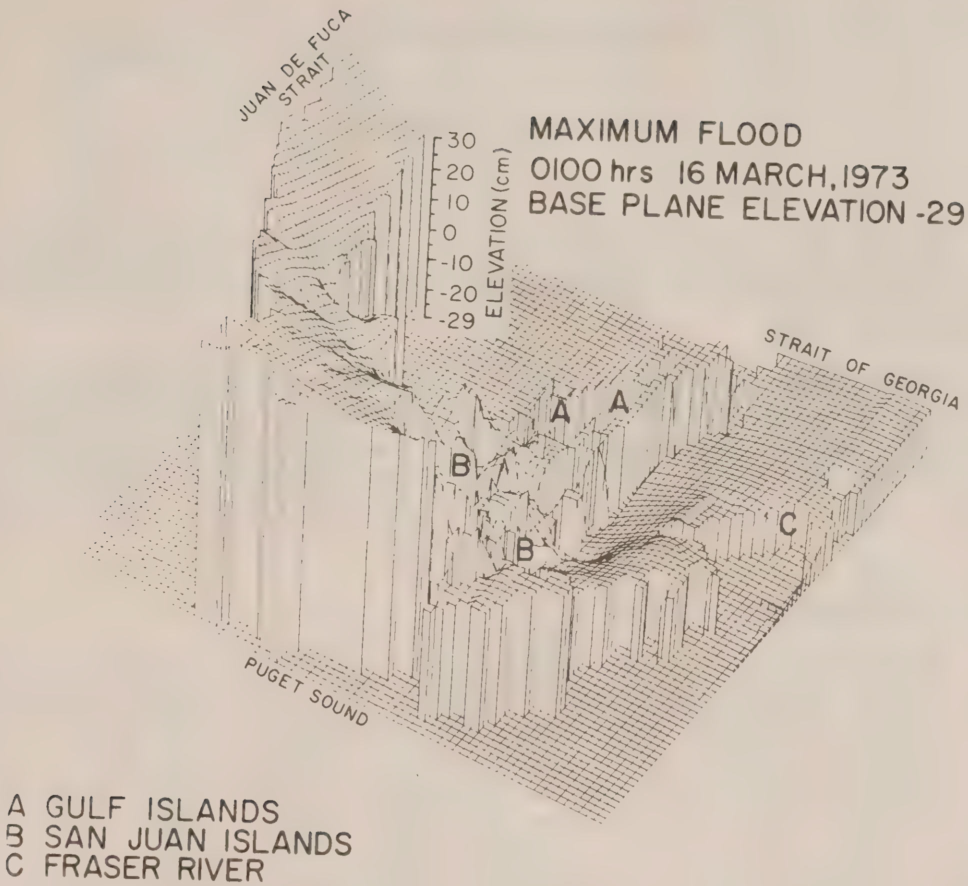
Tidal height and tidal current analysis and prediction programs used generally throughout the Department have been extensively revised and standardized.

Computed water surface elevations obtained from an overall barotropic numerical model which simulates the mixed tides between Vancouver Island and the mainland have been used to drive a more detailed model (2 km mesh size) of the southern Strait of Georgia, Juan de Fuca Strait and the region of the San Juan Islands. The tidal elevations and streams obtained from this latter model have been verified against observations for representative locations. An earlier attempt to operate such a local model using observed elevations proved unsatisfactory since its sensitivity was insufficient to permit proper frictional adjustments and also because of the inability of the tide gauges to provide adequate resolution of the small slopes along the open boundaries of the model.



Illustrative of the results obtained from this model, the figure above shows the distribution of velocity vectors when the flood streams are maximal during a tide of average range. Interesting features of these computed fields include the formation of eddies, evident along the northern shores of the inner part of Juan de Fuca Strait, which are associated with strong residual circulations.

The other figure shows the shape of the water surface for the same time as the flood streams shown above. The marked change in elevation across the San Juan Islands occurs from the heavy frictional dissipation in that area. Transverse slopes of the water surface which balance the geostrophic



accelerations of the incoming streams are evident in Juan de Fuca Strait and the Strait of Georgia.

The next major problem in these numerical model studies of the waters between Vancouver Island and the mainland concerns near-surface circulation in the Strait of Georgia. The Fraser River discharge moves out over the salt water in the Strait to form a shallow upper layer which is highly sensitive to the changing tides, river discharge and winds. The costs of numerical experimentation required for the study of so complex a physical system are greatly reduced if the water surface slopes and the underlying barotropic tidal velocities obtained from the above 2 km mesh model can be introduced directly into a "buoyant spreading" upper layer model simulating these shallow motions. A successful exploratory study has been completed demonstrating the efficacy of this technique. This is a continuing joint study with Dr. J. Stronach and Dr. Paul LeBlond of the Institute of Oceanography of the University of British Columbia. An accompanying program of field observations involving CSTD and current meter profiling, also drogue tracking, is being carried out using the Canadian Hydrographic Service launch *Brisk*.

REMOTE SENSING SECTION

J.F.R. Gower - Head

J.S. Wallace

The remote sensing section has responsibility for development of remote sensing techniques for oceanography and for evaluation of techniques originating elsewhere.

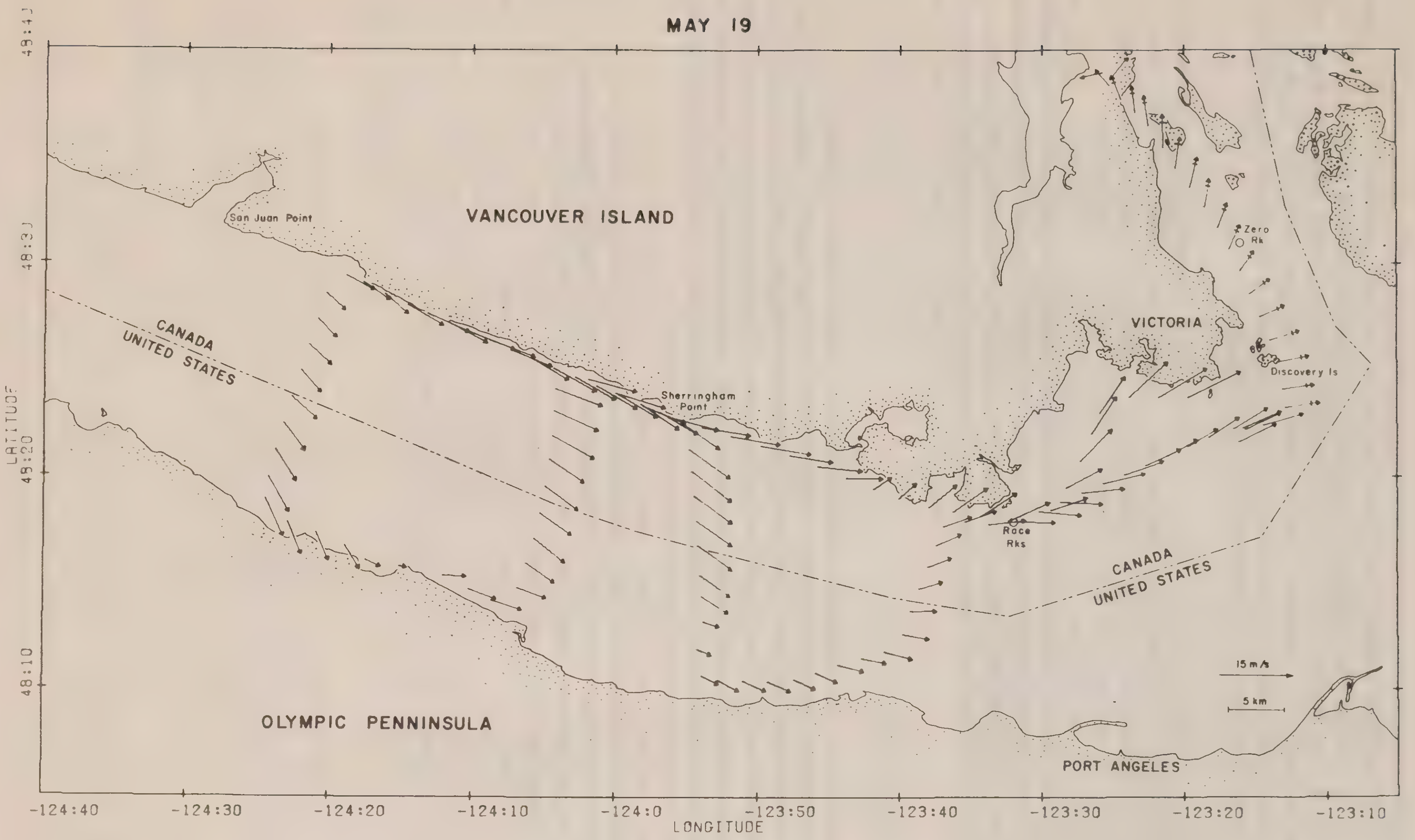
During 1977 the work of the section included projects involving measurement of waves by radar altimetry and synthetic aperture imaging radar, chlorophyll measurements by spectroscopy, mapping of near surface winds from aircraft, provision and processing of satellite imagery and provision of specialized aerial photography in support of the Institute's oceanography programs.

Satellite Oceanography

The first satellite specifically designed for studying the ocean, the United States National Atmospheric and Space Administration (NASA) SEASAT, will be launched in 1978. This has particular interest for Canada since its sensors will operate at high radio frequencies, in the microwave region of the spectrum, and therefore will not be affected by cloud cover that so frequently prevents aerial or satellite imaging using visible light over areas of interest to us. A Canadian program designed to investigate the capabilities of using satellites for surveillance (SURSAT) will evaluate SEASAT and contribute expertise to NASA's scientific planning teams for this satellite. J.F.R. Gower is a member of the team that is planning the imaging radar experiments.

Some of the potential uses of this imagery were demonstrated during an aircraft flight over the west coast of Vancouver Island when a synthetic aperture radar of the type to be launched on SEASAT produced pictures showing internal and surface wave patterns and coastal current boundaries. The wavelength deduced for the surface waves was in good agreement with data collected by the waverider buoy off Tofino. Images of similar resolution, but covering much larger areas will be provided by the satellite.

In addition to an imaging radar, SEASAT will carry a radar altimeter to measure wave and sea surface height, a scatterometer to measure sea surface wind, and a multichannel microwave scanning radiometer to measure sea surface temperature and to map ice cover. Different groups in Canada are studying the various applications of these and similar sensors. NASA has selected J.F.R. Gower to be one of the scientists to work on GEOS-3 radar altimeter data and the Remote Sensing Section has been evaluating this instrument for wave measurements and has developed an improved method of data analysis. These results will also apply for the SEASAT altimeter.



Plot of winds over Juan de Fuca Strait as measured by a low-flying aircraft. Near surface winds were measured by specially instrumented aircraft flying at less than 100 feet above the surface. Data will be used to predict the movement of oil spills under particular meteorological conditions.

Another satellite to be launched by NASA in 1978 is Nimbus G which will carry an instrument for mapping ocean colour, specifically those changes that are caused by varying amounts of floating plant life or phytoplankton in the water. The Remote Sensing Section has been evaluating the technique using a 256 channel spectrometer. During 1977 the first results of this study were published and the equipment is now being improved for further measurements in Europe and in the Arctic.

For the display and analysis of satellite imagery, the Section has put a digital picture production system into operation, which will allow special purpose enhancements to be made for a variety of ocean and Arctic projects.

Various other uses made of satellite imagery during 1977 include an analysis of vortex streets visible on the National Oceans and Atmospheric Administration (NOAA) polar and synchronous satellites and continuing observations of sea surface temperature patterns using thermal infrared scanning.

Airborne Oceanography

Operations in airborne coastal oceanography use a specially instrumented aircraft leased from the Provincial Government. During 1977 this was used principally for low level wind observations to be applied to modelling the movement of oil spills. The sighting system on the aircraft allows the positions of targets to be measured to an accuracy of 10 meters. Various tracking operations on drifting surface drogues were carried out to assist in the compilation of coastal current charts.

Other airborne work included photography of Knight Inlet to follow motion of the glacial silt repeated on 3 dates during the summer months. The silt colours the water very strongly and indicates fronts and internal waves as well as tidal currents.

ARCTIC MARINE SCIENCE

A.R. Milne - Head

B.D. Smiley R.H. Herlinveaux

Arctic activities in 1977 centred on the Beaufort Sea, the Sverdrup Basin in the Queen Elizabeth Islands, and Lancaster Sound at the eastern end of the Northwest Passage. These activities related mostly to marine oil-spill countermeasures and oceanography in support of environmental assessment requirements, and to a lesser extent, marine biology. Many of these activities were supported by the Polar Continental Shelf Project of Department of Energy Mines and Resources.

The Beaufort Sea

Four overview reports of the Beaufort Sea Project are in various stages of completion; two were published in 1977. These are: Oil Spill Countermeasures, and Birds and Marine Mammals. Demand for over 40 technical reports remained high, mainly on account of accelerated exploratory drilling in the Beaufort Sea by CanMar and from the many investigators engaged in the Alaskan Outer Continental Shelf Environment Assessment Program.

Plans to deploy 17 Random Access Memory Data Buoys around the rim of the Beaufort Sea were developed late in the year with buoy deployment by Twin-Otter expected early in January 1978. These will be complemented by several installed in the southern Beaufort Sea within drilling permit areas by CanMar and Imperial Oil (Canada) Ltd. and plans include use of remote sensing by aircraft. Several buoys, equipped with air pressure sensors, will add to meteorological data necessary to interpret ice drift. Objectives are to measure velocity shears in transition ice zones, to identify regions of ice which may enter petroleum exploration areas in summer and, to investigate characteristics of ice motion peculiar to the Beaufort Sea off M'Clure Strait.

Wave-rider buoys were again deployed in the southern Beaufort Sea in summertime in cooperation with Imperial Oil, Gulf Oil and CanMar. These were located off Kugmallet Bay, Pullen Island, Garry Island, Warren Pt. and CanMar drillships. Data from these buoys is available through the Marine Environmental Data Service (MEDS) in Ottawa.

Sverdrup Basin

The existence of oil at Cameron Island motivated the Department of Indian and Northern Affairs (DINA) to request studies on oil-spill pathways from possible oil pollution in the Sverdrup Basin. Several studies, partly funded by DINA, were initiated and included: (i) radar tracking of sea ice north of Byam Martin Island near an anticipated oil pathway,

Radar installation used for tracking ice in Arctic channels

(ii) a satellite imagery study of ice movement, encompassing several years' images, from which oil pollution trajectories were inferred and (iii) a longer-term study to analyze existing oceanographic data in the region to interpret water movements. Reports are presently available for the first two of these. A report on winter oceanography in Wellington Channel and eastern Barrow Strait will be available in January, 1978.

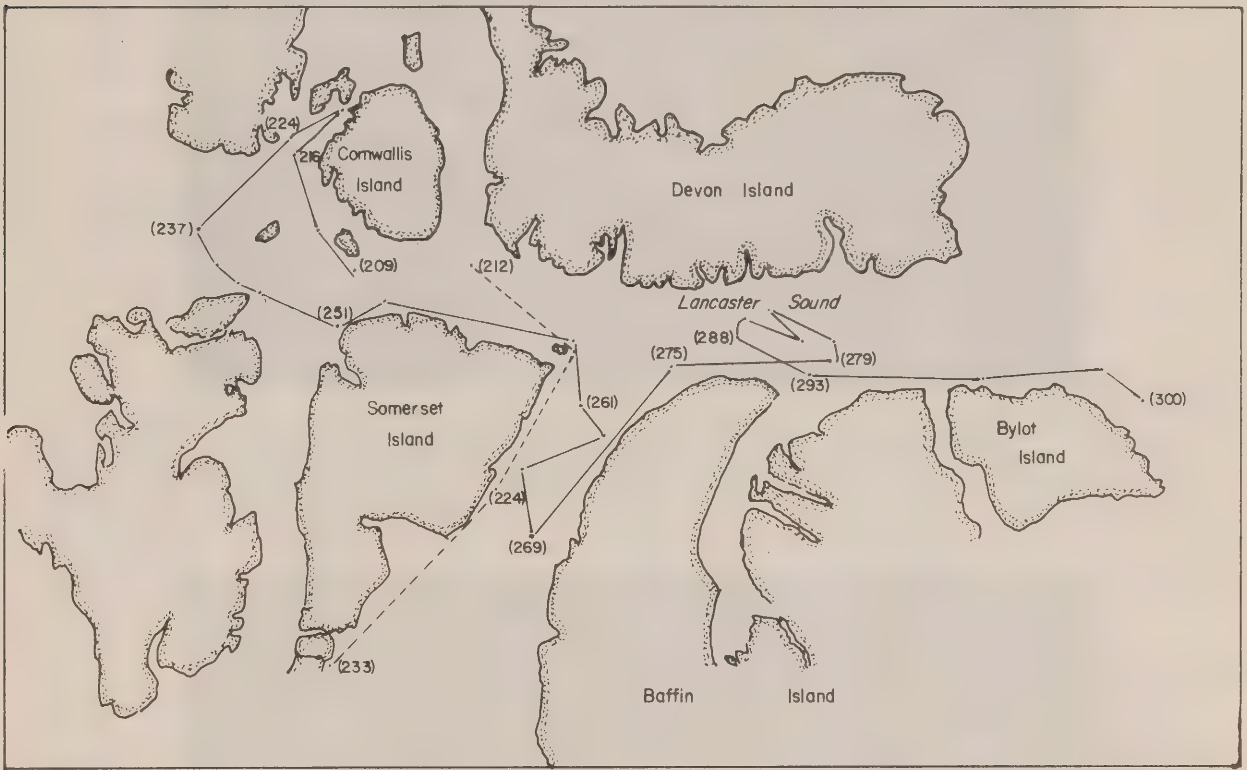
Oilspill countermeasure problems in multiyear ice focussed on the problem of how to deal with oil trapped under it. Oil under first year ice rises to the surface in early summer through brine channels and capillaries. The question was - when would it surface through multiyear ice? The Environmental Protection Service (EPS) funded a study on the seasonal variability of the porosity of multiyear ice. It was surmised that oil would likely surface in late September, when the body of the ice is warmest. To test this hypothesis the porosity of multiyear ice was measured at various times of the year. Findings indicated that in late September, or earlier, one would expect oil which was trapped under multiyear ice during the previous winter to surface.

Lancaster Sound

The environmental impact statement on possible effects of offshore drilling in Lancaster Sound is slated for completion in January 1978 and has been the most time-consuming work for two investigators during 1977. The considerable attention devoted to this assessment is warranted by the consensus that Lancaster Sound is by far one of the most biologically productive regions in the Canadian Arctic. Funding support for this task was provided by DINA.

Surface water movement studies in Lancaster Sound were funded by Environmental Protection Service under their Arctic Marine Oilspill Program (AMOP) and are related to the determination of oilspill trajectories. These comprised three main components: tracking drift-buoys in the open water of summer, tracking sea ice by radar through the breakup period from Griffith Island, in Barrow Strait, and complementary satellite imagery and meteorological studies of ice drift and surface water movements.

Ten drift-buoys, tracked by NOAA satellite, were deployed in eastern Barrow Strait at intervals during the summer. Their drifts provided many surprises, being contrary to expected drifts inferred from historical data. Interpretation of drifts was aided by weather data from portable weather stations installed cooperatively with Norlands Petroleum and the Defence Research Establishment Pacific. Radar tracked ice floes confirmed a clockwise water circulation around Griffith Island which moved a drift-buoy completely around the island.



Drift-tracks of two of the COSRAM satellite buoys.

Four current-meter moorings were set out in water depths of 750 m during August and September in eastern Lancaster Sound. Three moorings were recovered and redeployed for overwintering. The Ministry of Transport icebreaker *CCGS Labrador* supported field operations while EPS and Norlands Petroleum provided funding. A preliminary analysis has been completed in sufficient detail to provide data to Norlands for underwater oil-well drilling design. The deep-water currents also allow modelling of a deep-water oil-well blowout and shallower current measurements are of use in interpreting iceberg drift.

Current meters and buoys layed out on rail of *CCGS Labrador* ready for mooring in 750 meters in Lancaster Sound

"Equipment eating" icebergs in Lancaster Sound

OCEAN CHEMISTRY DIVISION

C.S. Wong - Chief of Division

W.J. Cretney
R.W. Macdonald
J.A.J. Thompson
R.D. Bellegay
W.K. Johnson
F.A. McLaughlin
P.S. Munro
D.W. Paton
D. Macdonald
J.S. Page (Computer Services)
T. Soutar (Chemical Instruments)
V. Stukas (Postdoctoral Fellow)
K. Iseki (Postdoctoral Fellow)

Visiting scientists:

K. Kremling (Institut für Meereskunde, University of Kiel, F.R.G.)
E. Matsumoto (Geological Survey of Japan)
R. Schmidt (Meteorological Institute, Frankfürt, F.R.G.)
D. Cossa (France; now at Rimouski University, Quebec)
J. Puize (Peches et Sciences de la Mer, Quebec)

Ocean Chemistry Division's primary responsibility is to understand the chemical aspects of the marine environment in B.C. coastal waters, the western Arctic and N.E. Pacific Ocean, and to assess the chemical effects of human activities on seawater, suspended matter and bottom sediments. These effects must be distinguished from large natural and often non-systematic variations. A secondary role is to provide chemical oceanographic information useful in fisheries research, in geological studies and in the study of water transport and mixing.

The major event for the Division is the final move to new facilities at Patricia Bay after a 1972 transfer from Nanaimo to a temporary location at 211 Harbour Rd. in downtown Victoria. These new laboratories include unique clean rooms for trace metals, hydrocarbons and pesticide studies, an underground vault for radiocarbon and lead-210 geochronology, mass spectrometer rooms, infrared calibrating and analytical areas, plus basic chemical laboratories for nutrients, heavy metals and oceanographic parameters. By joining other groups already at the Institute, a more fruitful interaction with other disciplines is anticipated.

Coastal Pollution, Bio-Uptake

(Thompson, Paton, Cretney, McLaughlin)

Point-source pollution by domestic and industrial outflows into the coastal environment has been a major concern of the public and regulatory agencies, such as the federal Environmental Protection Service (EPS) and the provincial Pollution Control Board. Problem areas include sewage outfalls at Macaulay Point and Clover Point where the City of Victoria is discharging domestic wastes, mining disposal sites in Howe Sound and Quatsino Sound and the ocean dumpsite at Point Grey in the Strait of Georgia. Chemists look at

the concentration of toxic compounds, both inorganic and organic, accumulated in the biota and in particular those in marine benthic organisms to assess if an overall danger level of pollutants is being taken up by the benthic food web.

Public hearings on waste disposal by mining industries in B.C. were held in Victoria recently, attended by Dr. Thompson, who assisted the government team in the inquiry by providing his expertise in heavy metal pollution gained from his studies at Britannia Mines in Howe Sound and Utah Mines in Quatsino Sound.

Bioaccumulation work was mainly supported by Ocean Dumping funds in the Point Grey dumpsite study. Data on heavy metals in marine benthic organisms in 1976-77 showed insignificant differences between the dumpsite and a control area nearby. The data was, however, insufficient statistically. Thus, a cruise was conducted in July 1977 to collect surface sediments, clams and mussels near the dumpsite, and also off the Victoria city sewage outfalls, for analysis of heavy metals (such as lead, zinc, copper, mercury, cadmium, chromium and arsenic) and organic pollutants (polychlorinated biphenyls and petroleum hydrocarbons). Some mussel collections were made along Juan de Fuca Strait for heavy metal studies and for baseline levels of petroleum hydrocarbons prior to heavy tanker traffic from Alaska.

Biotransformation of metal compounds, especially the methylation of mercury, is important in metal pollution problems. Under Ocean Dumping studies, field coring was conducted in Howe Sound. Much higher total mercury and methylmercury occurred near the chlor-alkali plant at Squamish, but methylmercury, the more toxic form, amounts to low values of less than 9 $\mu g\ kg^{-1}$ or 1% of total mercury. Laboratory biomethylation studies using radioactive ^{203}Hg tracer at 15°C demonstrated rapid methylation in the first 5 days, reaching a steady-state maximum in 10-25 days, then decreasing afterwards. Similar laboratory studies were conducted for Alberni sediments, which appeared to methylate much faster than Howe Sound sediments.

Chemical Oceanography

(R.W. Macdonald, Johnson, D. Macdonald, Bellegay, Munro, Wong, Barry)

To collect Arctic baseline data in the Amundsen Gulf area, chemical oceanographic and environmental studies were conducted on board the *Pandora II* in August, 1977 on a ship-of-opportunity basis in conjunction with the major hydrographic program. Seawater, surface sediment and plankton samples were collected for hydrocarbons and trace metals. Shipboard mercury determinations in seawater indicated low background levels similar to those in the Southern Beaufort Sea. Lack of strong influence from the Mackenzie River was evident from the high salinity. Similar nutrient maxima features to those observed in our 1975 Beaufort Sea studies confirmed the source of the Northern Beaufort Sea sub-surface shelf water to be from the Amundsen Gulf.

Coastal cruises were conducted approximately once per month in B.C. coastal waters for environmental studies. During February 4-16, a *Parizeau* cruise was carried out in the Kitimat-Porpoise Harbour area to obtain

seawater and zooplankton samples for hydrocarbons. Mussels were collected around Douglas Channel during beach walks by the landing party. Lead-210 dating of a core in the area suggested a high sedimentation rate of about 0.5 cm yr^{-1}, a fact which will strongly influence the fate of future contaminants introduced into the area. Three cruises were dispatched to the Alberni Inlet for work related to Ocean Dumping. Oxygen depletion in the Inlet was found above Stamp Narrows, but could not be related specifically to the effect of dumping. Cores and grab samples showed bark and wood chips overlying the upper inlet bottom, suggesting that such material from log booming grounds is more significant in causing de-oxygenation than dumping at the designated site. Summer oxygen depletion occurred in Howe Sound this year, a rare event in the past few decades. Several cruises were conducted throughout the year to study the oxygen changes and other possible chemical effects. No change in mercury levels in the water and anoxic sediments were detected. The severe de-oxygenation has caused mass mortality in the marine benthic fauna. The event could not be explained satisfactorily, although it was thought to be related to circulation affected by the abnormal Squamish River outflow.

Open-ocean effort was devoted to a continuing study of the long-term trends of chemical parameters at Ocean Weather Station P (50°N, 145°W). Neuston net tows were made between Victoria and Station P to collect tar balls and other surface pollutants. Samples of total dissolved aromatic hydrocarbons in surface waters were also collected. Weekly samples of atmospheric CO_2, surface alkalinity, total CO_2, surface radiocarbon were taken, together with continuous shipboard infrared measurements of marine air CO_2 and pCO_2. Samples of nutrients were taken to provide information about long-term fluctuations in relation to circulation and the marine food chain. The program also included collecting samples for trace metals.

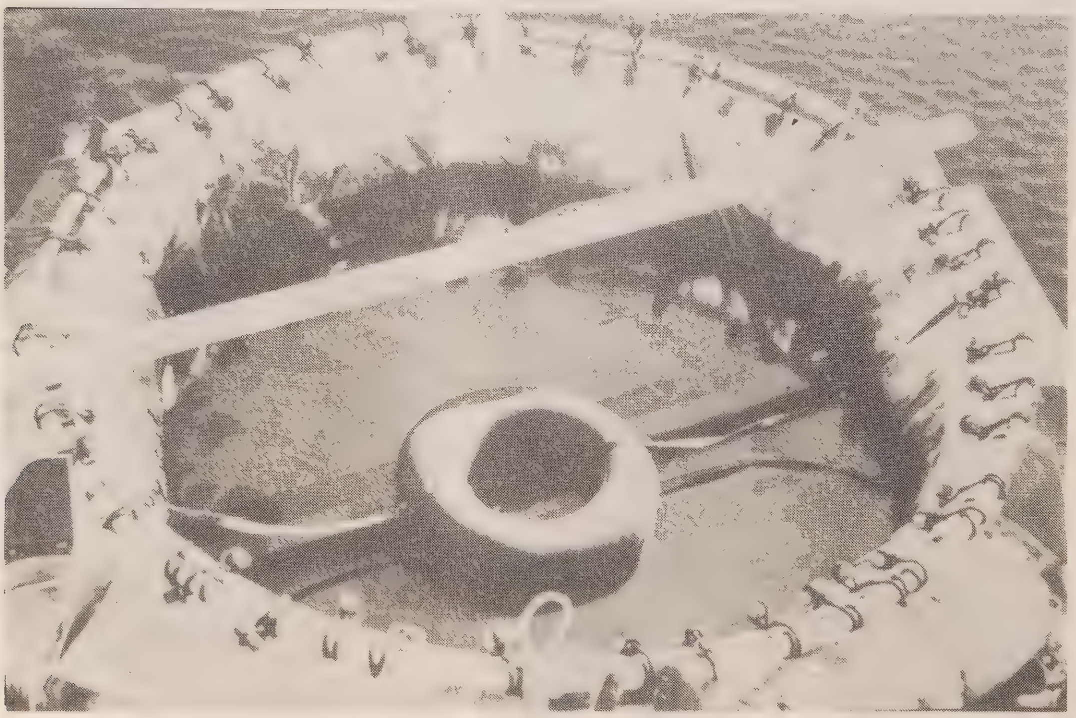
Collecting mussels, Kitimat,1977

Marine Hydrocarbons & Pesticides

(Cretney, Christensen, McLaughlin, R.W. Macdonald, Wong)

The objective of the program is to understand the occurrence, pathways and fate of hydrocarbons (natural, petroleum, polychlorinated byphenyls (PCBs) and pesticides) in the marine environment. The main effort was on a Controlled Ecosystem Pollution Experiment (CEPEX) to study the behaviour of emulsified oil and on establishing clean-room techniques for PCBs.

To understand the behaviour of Prudhoe Bay crude oil emulsified with a new commercial dispersant, Corexit 9527, a CEPEX experiment, funded by the Environmental Emergency Branch of EPS in Ottawa, was carried out September 26 to October 13 in Saanich Inlet. Instruments were developed on a crash basis for the study: an underwater photomicrographic apparatus to detect oil droplets in the micron diameter range, a modified small-size National Bureau of Standards (NBS) sampler to sample under slicks and a continuous flow-through fluorescence device capable of detecting 0.1 parts per million of emulsified oil. One large plastic bag, with about 60,000 liters of seawater, was spiked with 3 liters of Prudhoe Bay crude oil as a control and another with the crude oil emulsified with 150 ml of the dispersant. Results showed the dispersant to be effective immediately.



A CEPEX enclosure into which has been poured a mixture of Corexit 9527 in Prudhoe Bay crude oil

Underwater photomicrography apparatus

However, in 1-2 weeks, the emulsion flocculated to loose aggregates up to 1 cm across. Even after 2 days, the emulsified oil tended to lose chemical activity. Work is still in progress to perform gas chromatographic analysis on the samples and to construct an eddy diffusion model to explain the spread of emulsified oil into the water column.

Long-term weathering of oil spilled by the grounding of the ship *Irish Stardust* at Alert Bay in 1974 was summarized after a recent visit to assess the latest environmental changes. This summary was presented at a Halifax Symposium on Long-Term Fate of Oil in September, 1977. Oil composition, in particular cyclic triterpanes, was utilized in following the chemical degradation of the oil.

PCBs have been one of the more serious environmental concerns in recent years becuase of their persistence and toxicity in the environment. Analytical techniques are being developed using a gas chromatography with an electron-capture detector and gas chromatograph-mass spectrometer using all clean-room precautions to identify PCBs and pesticides in samples from local B.C. waters. One such study of the sediments in Porpoise Harbour, Prince Rupert, affected by a PCB spill by Cancel Ltd. was undertaken.

Trace Metals

(Wong, Kremling, Piuze, Matsumoto, R.W. Macdonald, Johnson, Stukas)

The main objective is to assess the natural and man-made inputs of physiologically significant trace metals into the marine environment and their interaction with suspended matter, planktonic biota and sediments.

For seawater, the key problem is the reliability of the sampling and analysis of trace metals at the ultra-trace levels. This analytical problem is crucial in our assessment of the state of the environment in the pristine waters of the Arctic and in open oceans, as well as in an understanding of trace metals released into seawater from sediments and particulates including material dumped into the ocean in concentrations approaching natural levels. Work funded by NATO is in progress on accurate measurements using clean rooms and mass spectrometry in cooperation with Dr. Kremling of Kiel, F.R.G. and Dr. J.P. Riley of Department of Oceanography, University of Liverpool.

Our main emphasis is on mercury. In response to an EPS western Canada mercury assessment, preliminary data were compiled for B.C. coastal waters: 8 nanograms per litre (ng ℓ^{-1}) in Howe Sound, 10 in Saanich Inlet and 21-29 in Alberni, Rupert and Neroutsos Inlets. These low levels indicated efficient removal mechanisms from seawater, since the Howe Sound waters sampled were near a chlor-alkali plant. A sediment survey of mercury contents suggested a low background level of 0.05 μg g^{-1} near the Squamish River estuary but "hot spots" of 7 μg g^{-1} were found around the plant. Another hot spot of over 1 μg g^{-1}, detected in a sediment layer between sand 4 and 20 cm below the sediment surface off Watts Point in Howe Sound, was shown by lead-210 geochronology to be relict, introduced at least 40 years ago.

Sampling dredge spoils in Victoria's Inner Harbour for Determination of trace metals, hydrocarbons and other environmental contaminants

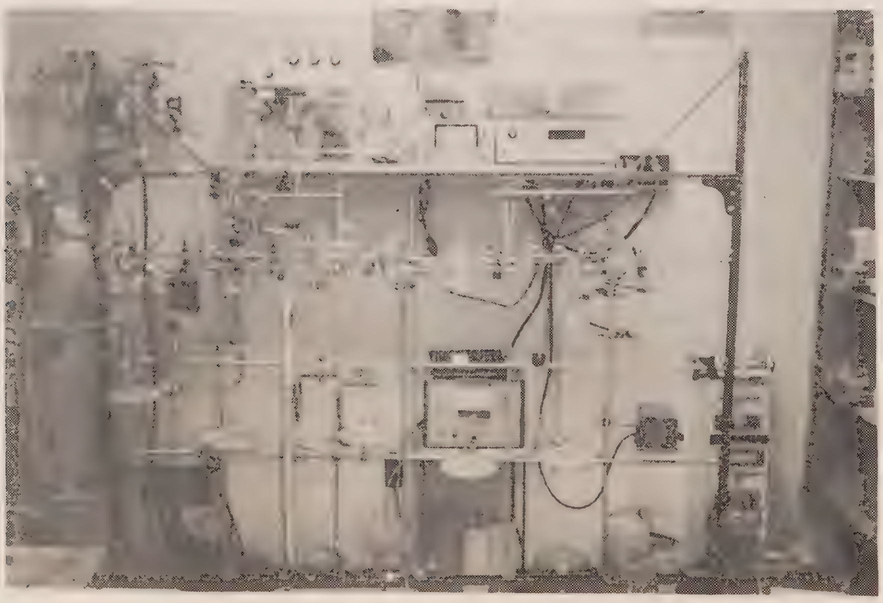
Mercury release from resuspended sediment in Howe Sound contaminated with mercury was studied in the laboratory as part of Ocean Dumping work. Mercury release occurred rapidly from suspended sediment into seawater within a few hours. This process then moved more slowly towards equilibrium in a few days being accelerated mainly by low pH and high salinity but unaffected by temperature, storage condition or biology. The flux across the sediment-estuarine water interface was found to be about 100 ng cm^{-1} day^{-1}. Field work showed tidal action to be a major mobilizing mechanism for mercury in the estuary.

A survey of the copper release problem in a marina near Sidney was carried out in the summer. Laboratory study indicated a rapid leaching of copper from a surface painted with an anti-fouling paint. However, no significant accumulation of copper was detected in the marina sediments. A project on accumulation of tetraethyl lead in marine sediments was also initiated by establishing a gas-chromatograph/atomic absorption technique and isotope dilution technique for detection of minute quantities of tetraethyl lead and the isotopic ratio of lead in gasoline respectively.

The trace metal sedimentation rate in Saanich Inlet was studied by using a lead-210 dating method together with determination of trace metal concentrations in seawater. Lead was removed from the water very rapidly. A residence time of 0.08 years was inferred for lead-210, 0.07 for other lead isotopes, 0.3 for copper, 3 for cadmium and 2 for mercury in the coastal inlet. These residence time scales were in line with preliminary results of CEPEX work here, where lead added at the parts per billion level to the water was quickly removed as detritus in the first 5 days, and where any cadmium added would have less than 1 percent removed after almost one month.

Our Division is in our fourth year of association with CEPEX (Controlled Ecosystem Pollution Experiment), an International Decade of Ocean Exploration program managed by the Institute of Oceanography, of the University of British Columbia at the site of our Institute at Patricia Bay. Our Division continued to host international scientists Dr. Kremling of Federal Republic of Germany, Dr. D. Cossa of France under a Canada/France Scientific Cooperation Program, Dr. Matsumoto from the Geological Survey of Japan. Dr. Piuze, formerly with Ocean Chemistry, also participated from Quebec Region. A tracer experiment was conducted August 6-26 using three bags with 60,000 liters of seawater each. One was used as a control, a second was spiked with minute quantities of lead-210 (1.5 micro Curries (μC)) and cadmium, and a third with 0.5 μC of radiocarbon. Isotopic lead-210 used as a tracer for budget studies showed a much better recovery in the order of 85-100% of the amount injected compared to a much lower value for non-radioactive lead. This proved advantageous in its continued use as a tracer in preference to common lead. Work is still in progress on data processing.

Smith-McIntyre sediment grab sampling
at the Port Alberni ocean dump site



Apparatus for total CO_2 extraction from
seawater samples from the weatherships at Station PAPA

Marine Carbon Cycle

(Wong, Bellegay, Munro, Iseki, Page, Rennie)

The global carbon cycle is receiving much attention in the scientific community because of man's increasing reliance on fossil fuel sources due to population pressure and strong public reactions to nuclear power as an alternative. There are serious debates on the possibility of climatic warming as a result of an atmospheric carbon dioxide (CO_2) increase, on the relative importance of the biota and the ocean as a CO_2 sink and on the political and economic consequences of turning to coal as our energy source after depletion of petroleum. Scientific challenges are encountered in our quests for solutions in these energy-related debates. The on-going research in Ocean Chemistry is contributing some new insights into the marine aspects of the global carbon cycle in attempts to meet such challenges.

The CO_2 time-series at Ocean Weather Station P (50°N 145°W) is in the ninth year of documenting the increase in background atmospheric CO_2 over the ocean. It forms an important data base for our understanding of air-sea CO_2 interaction. By analysis of the CO_2 content in weekly air samples and continuous air and seawater partial pressure of carbon dioxide (pCO_2) measurements by infrared instruments, we detected an unexpected static CO_2 level in both 1975 and 1976 contrary to the currently accepted notion of atmospheric CO_2 increase. This implies some uncertainty in our knowledge of how atmospheric CO_2 behaves and throws models of CO_2 prediction in the atmosphere into serious doubt. Another unexpected finding is the much higher pCO_2 in surface waters than in the air at Station P in the summer, contrary to the accepted concept of the ocean waters in northern latitudes acting as a CO_2 sink in summer. These findings were presented in the Seattle International Association of Meteorology and Atmospheric Physics on the Carbon Cycle.

The most recent efforts to compile an accurate inventory of sources of atmospheric CO_2 for use in constructing global CO_2 models, have unexpectedly indicated that contributions derived from forest fires and tropical shifting cultivation are more important than previously thought, being at least 30% of the present-day burning of coal, gas, petroleum and limestone. A new hypothesis advocating enhanced marine detritus formation as a CO_2 removal mechanism has been proposed as an alternative to the known CO_2 sinks, namely the ocean and the land biota. Dr. K. Iseki of Tohoku University in Japan joined Ocean Chemistry in late 1977 to start work related to detritus carbon for evidence of such mechanisms by planning detritus carbon time-series experiments at Ocean Weather Station P, and marine detritus carbon studies using CEPEX enclosures.

In addition to Station P CO_2 analysis, our infrared laboratory has been performing air CO_2 analysis and reference gas calibrations for other Canadian CO_2 stations at Sable Island in the Atlantic and at Alert in the Canadian Arctic, both manned by the Atmospheric Environment Service. Instrument development was pursued under a NATO grant, in cooperation with Dr. R. Schmidt of Meteorological Institute at Frankfürt, Federal Republic of Germany on adapting his water-correcting CO_2 analyzer to measurements of partial pressure of CO_2 in seawater and for air-sea CO_2 flux studies using aircraft.

OCEAN ECOLOGY LABORATORY

R.O. Brinkhurst - Head

M.J. Austin	G. Gardner (Postdoctoral Fellow)
K. Denman	D. Mackas (Postdoctoral Fellow)
	P. Chapman (Graduate Student)

In its second year the Ocean Ecology Laboratory (OEL) moved from the hangar to an old cottage and then into the new Institute building. Dr. Ken Denman joined the laboratory, transferring from the Marine Ecology Laboratory of the Bedford Institute of Oceanography, as did Dr. Dave Mackas from Dalhousie University on a Visiting Fellowship. With increased allocation of summer students, and recent Federal Labour Intensive Programme technicians plus internal allocation of a term technician OEL has been able to pursue an active field program as well as laboratory investigations and planning of future projects.

In February 1977 Ocean Ecology Laboratory hosted a workshop to investigate the feasibility of using regularly scheduled commercial ships and tankers (ships-of-opportunity) to collect, in a cost-effective manner, the large amount of data needed for a long time series of biological, physical and chemical oceanographic information from B.C. coastal and shelf waters. Local representatives from the universities, industry and government as well as scientists from the United States and Britain attended. One of the conclusions identified a need in the Region for a time-series of oceanographic and biological information along the Canadian shelf to provide background for studies of ocean climate, environmental disturbances such as build-up of hydrocarbons or CO_2 level changes in the atmosphere, and for fisheries managers seeking anomalies that can be related to survival of young fish at sea. The combination of severe weather and lack of adequate platforms has made the shelf difficult of access, and this remains the major problem.

Since then discussions and planning have continued, and it is hoped that a pilot field program will be initiated before the end of 1978 in cooperation with Dr. T.R. Parsons, Institute of Oceanography, University of British Columbia.

To complement the ships-of-opportunity program, several projects have been initiated within OEL.

Dr. Gardner led two cruises to the major mainland inlets and near-shore coastal waters north to Dixon Entrance. Data from these cruises provide the first extensive characterization of British Columbia marine zooplankton communities. Without this fundamental information we can only guess at the impact of man-made and natural environmental changes on fisheries and other coastal resources.

Two shorter cruises, utilizing the University of Victoria's motor launch *John Strickland*, were carried out along a line of stations from the Strait of Juan de Fuca to the Strait of Georgia near Nanaimo. These cruises examined the effect on the zooplankton of the annual intrusion of offshore water into the Strait of Georgia. Long term changes in the composition of the intruding water appear to contribute to long term changes in the zooplankton community of the Strait; however, the mechanisms responsible for the changes are as yet unknown. In addition, intruding water may transport zooplankters normally found offshore into inshore waters, and be responsible for maintaining populations of some of these species locally.

The above studies were designed to establish baseline data which will be used to plan further, more intensive, programs. The long term goal of this aspect of the plankton program is to increase our understanding both of the processes involved in zooplankton community evolution and of food chain interactions within the communities.

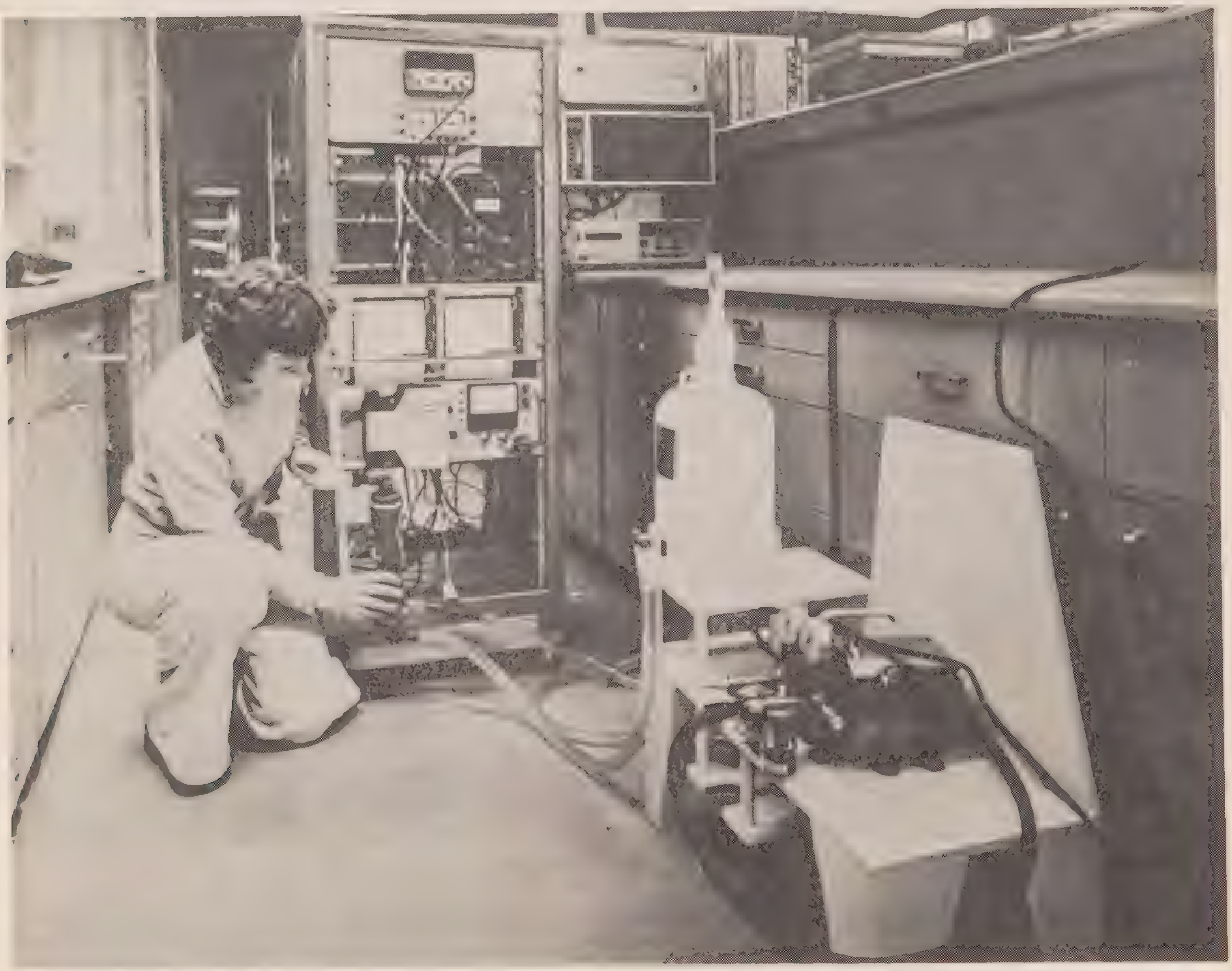
Progress has also been made in expanding the zooplankton species reference collection started under contract last year. Descriptions of the species, which we hope will ultimately lead to the construction of a new key to B.C. marine zooplankton, are slowly being accumulated.

Since his arrival in late June, Dr. Mackas has assembled and tested most of the components of an electronic plankton sampler. With the assistance of Ms. Austin, he also evaluated methods for extraction and analysis of phytoplankton pigments (required for field calibration of the electronic sampler). He spent 1½ months with the joint Canada-Peru ICANE cruise aboard CSS *Baffin*, where he operated and maintained a similar electronic system.

Dr. Denman is actively planning a joint multidisciplinary study of the oceanographic factors affecting the planktonic and fisheries production on the continental shelf of either the outer approaches to Juan de Fuca Strait or Queen Charlotte Sound in cooperation with Coastal Zone and Offshore Oceanography Sections of Ocean Physics Division.

In addition to administrative responsibilities for Ocean Dumping operations and research, running the laboratory and looking after the Science Subvention program and summer students for the Institute, Dr. Brinkhurst has maintained an active field and laboratory program. Material from overseas has led to the completion of a study of the zoogeography of oligochaeta in Europe, a study of rare and interesting Tasmanian species, and completion of a first review of the Canadian fauna. Work has begun on a revision of the marine oligochaetes of the world. In laboratory work he and Ms. Austin were finally able to complete a long study of energy flow through worm communities by obtaining reasonable estimates of ingestion of food by these animals that mineralize organic sludge or silt. The study of the bottom fauna of the Fraser suggests that the concentration of salt in the bottom mud responds quite slowly to changes in the water column salinity, and so

the transition zone between the freshwater and saltwater species is quite sharp and seems to shift seasonally in relation to run-off and tidal rhythms. Mr. Chapman is carrying out experimental work based on his field results.



Electronic plankton sampler

On an invitation from the Pacific Geoscience Center, the Lab is attempting to identify the benthos on their photographs of the sea bed on the continental shelf and slope. This may lead to identifying benthic communities on a broad scale.

SHIP DIVISION

E.N. Geldart - Regional Marine Superintendent

F.S. Green - Assistant Marine Superintendent (Deck)
D. Marr - Assistant Marine Superintendent (Engineering) to September 17, 1977
R.W. Parkinson - Assistant Marine Superintendent (Engineering) from December 1, 1977

Mr. D. Marr, Assistant Marine Superintendent (Engineering) retired from the department September 17, 1977. His position has been filled by R.W. Parkinson, Chief Engineer *Parizeau*. Mr. G. Kyle has been promoted to Chief Engineer *Parizeau*.

The Pacific Region Ship Division provided ship, submersible, launch and depot support for the 1977 hydrographic and scientific programs and for several federal departments and universities.

CSS *PARIZEAU* (64.3 m overall - 1929 metric tons)

Master: A.G. Chamberlain Chief Engineer: R.W. Parkinson

Following annual drydocking and refit at Yarrows Ltd., Victoria, B.C., CSS *Parizeau* was employed in support of scientific and hydrographic programs, Ocean and Aquatic Sciences, Tides and Currents, Ocean Chemistry, Loran 'C' calibration, Offshore Oceanography; Defence Research Establishment Pacific, Ocean Acoustics; Department of National Defence, diver training; Simon Fraser University, Biology.

She was converted to hydrographic configuration and carried out hydrographic surveying in the Caamano Sound area from June 15 to August 31, 1977. She was then converted to tidal oceanographic configuration and carried out various scientific programs.

CSS *WM. J. STEWART* (65 m - 1720 metric tons)

The *Wm. J. Stewart* is decommissioned at the Patricia Bay wharf. The Ship Division office moved from here into the new Institute office during the latter part of May.

CSS *VECTOR* (39.6 m - 505 metric tons)

Master: J.C. Marston Chief Engineer: J.J. Peat

The CSS *Vector's* annual drydocking and refit was carried out at Yarrows Ltd., Victoria, B.C. During the year she carried out the following programs for Ocean and Aquatic Sciences, Ocean Chemistry, Loran 'C' calibration;

for Pacific Environment Institute, Biology, Ecology; for Institute of Oceanography, University of British Columbia, Physics; for Environmental Protection Service, Biology; for Energy Mines and Resources, Earth Physics.

CSS *RICHARDSON* (19.8 m - 76 metric tons)

Master: M.G. Wheeler Chief Engineer: I.N. Henderson

The CSS *Richardson's* annual refit was carried out at Burrard Shipyard and Marine Railway, Vancouver, B.C. During the year she carried out the following programs for Ocean and Aquatic Sciences, Side scan sonar, Coastal Oceanography, Tides and Currents, Revisory Survey; for Energy Mines and Resources, Geology, Side scan sonar; for Defence Research Establishment Pacific, Instrument testing; for Pacific Environment Institute, Ecology; for Inland Waters Directorate, Water quality.

M.V. *RADIUM EXPRESS* (22.2 m - 100 metric tons) on charter

Master: J.P. O'Sullivan Chief Engineer: W. Riggs

This vessel carried out a successful survey season covering the Mackenzie River and Mackenzie Bay areas.

M.V. *PANDORA II* (58.2 m - 220 metric tons) on charter

Master: R. Jones Chief Engineer: C. Tuck

The *Pandora II* with *Pisces IV* were employed in the following programs for Ocean and Aquatic Sciences, *Pisces IV* pilot training and certification, Ecology, Coastal Oceanography, Ocean Chemistry; for U.Vic. Biology; for Environmental Protection Service, Biology; Energy Mines and Resources, Ecology and Geology; for Institute of Oceanography, University of British Columbia, Sediment sampling.

She departed Patricia Bay for the Western Arctic June 30, arriving at the survey area in Amundsen Gulf July 25. The survey program was terminated and the vessel departed the area September 10, arriving at Patricia Bay September 27.

She was employed in a recovery program for United States Environmental Protection Agency off San Francisco from October 13 to November 1.

PISCES IV (6.1 m - 12 metric tons)

Chief Pilot: I. Sanderson

The *Pisces IV*, a deep diving submersible, was engaged in training three new pilots, a sponge study for the University of Victoria, a survey of ocean dumpsites for Environmental Protection Service, a geological survey of the continental shelf for Energy, Mines and Resources, and a simulated gas well blowout for Frozen Sea Research Group. In August she was flown to

Resolute Bay in a D.N.D Hercules aircraft and operated from *HMCS Preserver* in support of a Defense Research Establishment Pacific program.

A new improved ballast system was installed and all the syntactic foam on the submersible was replaced. A major refit saw the submersible completely disassembled, inspected and re-assembled.

CSL *REVISOR* (11 m - 10 metric tons)

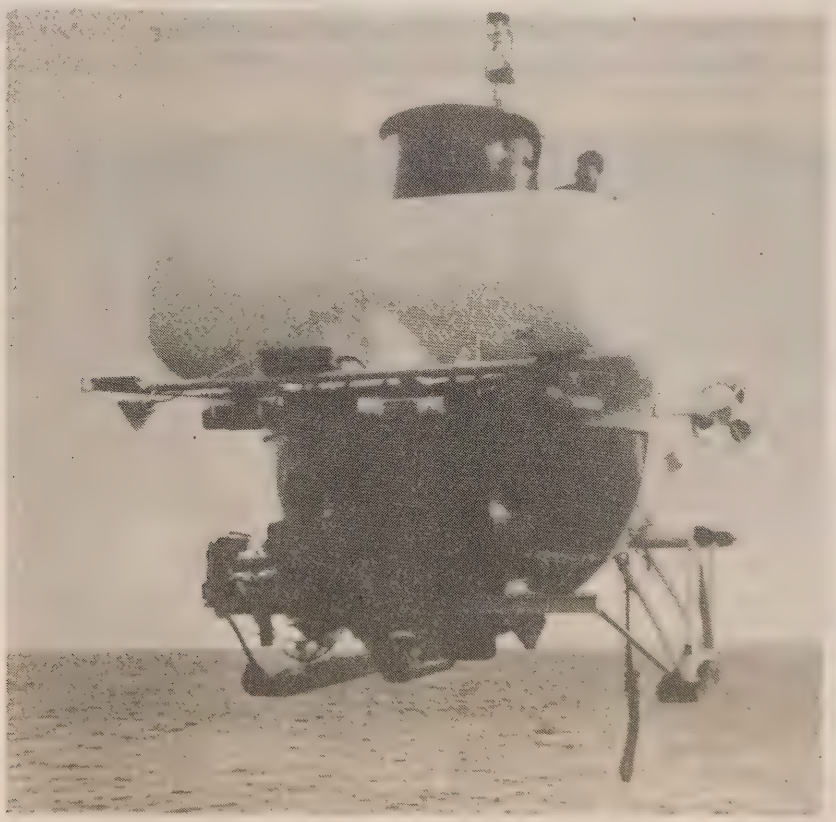
The launch *Revisor* was used in various minor programs and was used by the Canadian Wildlife Service for seabird surveys in the Strait of Georgia.

LAUNCHES

Survey launches were employed by shore-based hydrographic survey parties working in Vancouver Harbour and Saanich Inlet areas.

DEPOT

The depot workshops provided full support to all Institute groups, supplying mechanical repairs in the shop and in the field, metal fabrication, furniture building and fulfilling a multitude of requests.



Submersible, *Pisces IV*

MANAGEMENT SERVICES DIVISION

N.A. Todd - Chief of Management Services

Institute of Ocean Sciences - Construction

The end of the construction program is almost in sight. We had a good year in 1977 with no work stoppages of any consequence and construction pretty well on schedule.

Ocean Physics Division and Ship Division Management moved into their new premises in May. Hydrography and Management Services moved from downtown Victoria to Pat Bay at the beginning of September. Ocean Chemistry will joint the remainder of us at Pat Bay in January, 1978. At that time all of the units making up Ocean and Aquatic Sciences, Pacific Region will be under the one roof for the first time.

With the approval in August by the Treasury Board of an additional $1.4 million, completion of all the essential components of the Institute came within reach and we are now able to look forward to being able to walk on grass and not mud and to eat a hot mid-day meal in the Cafeteria.

Already the Institute is becoming something of a landmark in the Victoria area and is arousing curiosity and comment (mostly favourable) from residents and visitors.

Administration

The move from Government Street to Patricia Bay, some 30 kilometers, was carried out more smoothly than was anticipated. Our financial statements and other reports were produced with almost uninterrupted regularity. The time required to process some financial transactions did increase towards the end of the year due largely to an increase in their number.

Continuing progress was made in getting the Materiel Management Inventory Control System fully operational. A large proportion of the sections are now 'on line'. Although the system is not yet thoroughly proven, it gives every indication of meeting all requirements.

The role of administration in the operations and activities of the Institute is essentially a support role and makes a lengthy report here inappropriate. For those of us within the Division, 1977 was, all in all, not a bad year.

LIBRARY

Sharon Thomson - Librarian

C. Firth

1977 was a banner year! After five years of planning and making do with crowded conditions the Library moved to its spacious new quarters in the Institute. We have at last been able to recall the various office collections and house them all in one space, making things much more accessible to all users. Losses, though large, were not as great as we had anticipated.

The increases in book and journal prices, accompanied by a sharp decline in the Canadian dollar have forced very careful examination of all purchases, but the collection has continued to grow. Eliminating some duplicate subscriptions needed when we were in so many locations has enabled us to increase the number of journal titles received.

1978 promises to be a very exciting year, too. We expect to incorporate the bulk of the Ocean Chemistry collection when that group moves here early in the year and we expect significant increases in our holdings and in the subject areas covered when the collections of Earth Physics Branch and part of the Geological Survey of Canada are received and incorporated.

TASK FORCE, COMMITTEE AND SIMILAR ACTIVITIES

DIRECTOR-GENERAL'S OFFICE

Stewart, R.W.

Joint Organizing Committee (JOC) of the Global Atmospheric Research Program (GARP)

Canadian National Scientific Committee for GARP

Scientific Committee on Oceanic Research (SCOR) - member executive committee

SCOR - IAMAP - IAPSO Working Group on Air-Sea Interaction Research (COSPAR) - Canadian delegate

Sea Use Council (Canada-USA) - vice-chairman

Regional Board, Pacific Region (DOE)

Regional Board, Pacific Region, Executive Committee - A/chairman

Regional Board, Western and Northern (DOE)

National Research Council of Canada - GARP Grants Advisory Committee

Physical Oceanographic Commission (IAPSO) - president

Arctic Environmental Steering Committee

Arctic Waters Oil and Gas Advisory Committee

Royal Society of Canada Interdisciplinary Selection Committee

Vancouver International Airport Panel Member

American Meteorological Society - Councillor

Cornford, A.B.

Canadian representative to the Intergovernmental Oceanographic Commission (IOC)

Working Committee for Global Investigations of Pollution in the Marine Environment (GIPME)

HYDROGRAPHIC DIVISION

Ages, A.B.

Environmental Emergency Working Group, Victoria Zone

Coastal Water Pollution Group, Committee on the Challenges of Modern Society, NATO

Navigational Relative Risk Index Sub-group

Technical Committee (DOE), Annacis Island Sewage Treatment

Bolton, M.

Canadian Institute of Surveying - Councillor-at-Large
DOE Kitimat Oil Pipeline Working Group
DOE Mackenzie Basin Committee
Hydrographic Committee CIS - chairman
National Cartographic Appraisal Board
National Hydrographic Survey Officers' Appraisal Board
National Hydrographic Training Committee
New Research/Survey Vessel Users Design Committee - chairman
Pacific Sub-Committee on Oceanography of CCO - MEMBER
Research Ship Scheduling Committee
Joint DOE/DEMR Guiding Committee of Offshore Surveys
International Hydrographic Technical Conference - chairman

Curran, T.A.

Electronics Technology Program Advisory Committee, Camosun College

Galloway, J.L.

Steering Committee for the Establishment of International Shipboard Data Acquisition Standards

Huggett, W.S.

New Research/Survey Vessel Users Design Committee
Environmental Emergency Working Group, Victoria Zone

O'Connor, A.D.

Canadian Institute of Surveying, Victoria Branch - chairman

Rapatz, W.J.

B.C. Civil Defense Tsunami Committee
Ocean Dumping Act - inspector

Sandilands, R.W.

Hydrographic Technical Committee, Canadian Institute of Surveying
The Canadian Surveyor - associate editor (hydrography)
Canadian Hydrographic Association - associate editor
Survey Technology Advisory Committee - Camosun College
Workshop Group on Offshore Surveys for Mineral Resource Development
Board of Trustees, Maritime Museum of B.C. - immediate past chairman
International Hydrographic Technical Conference Committee (1979) - member

Smithers, F.R.

Public Information Group, DOE Pacific
Regional Committee on Interagency Routing of Navigational Information
Advisory Board, Camosun College

Watt, J.V.

Electronics Technology Program Advisory Committee, Camosun College

Wills, R.

Regional Hydrographic Survey Officers' Appraisal Board - chairman
Regional Committee on Interagency Routing of Navigational Information
Survey Technology Advisory Committee, BCIT
Regional Board, Pacific Region, Estuary Working Group

Wigen, S.O.

Appointed, during 1977 as National Representative to the International Coordination Group for the Tsunami Warning System in the Pacific

OCEAN CHEMISTRY DIVISION

Cretney, W.J.

Laboratory Safety Committee, Ocean Chemistry - chairman

Macdonald, R.W.

Ocean Dumping Technical Committee, Pacific Region

Thompson, J.A.J.

Pat Bay Safety Committee
Laboratory Safety Committee, Ocean Chemistry
Pacific Nuclear Activation Research Association

Wong, C.S.

Advisory Committee - Chemistry, CEPEX
Environmental Contaminant Act Advisory Committee, Pacific Region

OCEAN ECOLOGY LABORATORY

Brinkhurst, R.O.

Hon Prof. - University of Victoria
Canadian Society of Zoologists - Chairman, Science Policy Committee
Regional Ocean Dumping Committee - OAS Representative
Science Subvention Program Review Committee - Regional OAS Representative
Standards Council of Canada - ISO/TC 147/ Sc 5
Local Arrangements Chairman - A.S.L. Oligochaete meetings, Victoria 1978
Chairman, First International Aquatic Symposium 1979
Graduate Students, U. Victoria, U. New Brunswick

Denman, K.L.

Canadian Meteorological and Oceanographic Society Citations Committee

OCEAN PHYSICS DIVISION

Farmer, D.M.

Babine Lake Steering Committee
RODAC Technical Subcommittee
Canadian Meteorological Society, Oceanographic Division - Chairman

Garrett, J.F.

Canadian National Committee for SCOR
Committee of Participants for the Drifting Buoy System for the FGGE (Chairman)
Subgroup of Experts on Products and Services of IGOSS for the FGGE

Giovando, L.F.

Joint Working Committee Lower Fraser River Environmental Monitoring
B.C. Coastal Zone Resource Subcommittee
Roberts Bank Environmental Subcommittee

Gower, J.F.R.

Canadian Advisory Committee on Remote Sensing, Working Group on Oceanography - chairman
National Research Council Associate Committee on Space Research
NASA SEASAT Synthetic Aperture Radar Experiment Team - associate member
DOE Committee on Remote Sensing

Lewis, E.L.

UNESCO/SCOR/IAPSO/ICES Joint Panel of Experts on Oceanographic Tables and Standards (SCOR W.G. 10)
SCOR/IAPSO Working Group 51 - Evaluation of CTD Data
SCOR Working Group 58 - Arctic Ocean Heat Budget
Canadian Committee on Oceanography Panel on Ice - Arctic Oceanography Subcommittee
Marine Science Communications - Editorial Advisory Board

Milne, A.R.

Arctic Marine Oilspill Program Advisory; Committee member
Arctic Islands Pipeline Project Studies; Board member
Polar Gas Pipeline Project; EARP panel member
Arctic Region Ocean Dumping Advisory Committee member
Canadian Advisory Committee on Remote Sensing, Working Group on Ice

Miyake, M.

Canadian GARP Scientific Committee
NCAR Aircraft Facility Evaluation Committee
Executive Committee Mixed Layer Experiment, U.S. Office of Naval Research
Associate Editor "Boundary Layer Meteorology"
Honarary Associate Professor - Institute of Oceanography, Univ. of B.C.

Nasmyth, P.W.

Joint Group of Experts for IGOSS - Subject Leader
PhD. supervisory committee for Andre Langlais - UVic (Chemistry)
IOS Library Committee (Chairman)

Smiley, B.D.

Fate and Effects Working Group of Advisory Group on Research and Development and Member (EPS-AGRAD) Petrocan Environmental Advisory Committee; member

Tabata, S.

Ocean Climate Panel of Working Group 48 of the Scientific Committee on Oceanic Research (SCOR)

Thomson, R.E.

RSCC Task Force on the Proposed Floating Dry Dock, Burrard Inlet
B.C. Climatological Coordinating Committee
Editorial Committee, Atmosphere-Ocean

OCEAN ENGINEERING

Teng, K.

West Coast Electronic Data Processing Coordinating Committee, DFE
Organizing Committee for CIPS/ACM Northwest '78 Regional Computer Conference - General co-chairman

Johns, R.E.

West Coast Electronic Data Processing Coordinating Committee, DFE
Canadian Information Processing Society, Victoria Section - Treasurer

SPECIAL SERVICES SECTION

Smith, G.R.

Advisory Board on Marine Technology, B.C. Research

SHIP DIVISION

Geldart, E.N.

Pacific Regional Resource/Survey Vessel Committee - secretary

SCIENCE RELATED CONTRACTS AWARDED IN 1977

Preparation in digital form of oceanographic data for Fraser River plume, P. Stoddart, Vancouver, B.C.	1,012
Collating and plotting of oceanographic data G. Wallace, Sidney, B.C.	950
Development of analytical techniques for measurements of concentrations of natural and anthropogenic hydrocarbons in seawater, marine organisms and marine sediments, P.A. Christensen, Sidney, B.C.	19,500
Calibration of special current meters Applied Microsystems Ltd., Victoria, B.C.	445
Development of a computer program for hydraulic research Apocalypse Enterprises Inc., Victoria, B.C.	19,440
Development of a timing system for Pisces IV stabilizing fins Canadian Aircraft Products, Richmond, B.C.	5,453
Study of the amplitude and phase of a tidal constituent on open boundary of a coastal area I. Barodale, Victoria, B.C.	2,500
Development and design of an electronic clock for unattended tide gauges Applied Microsystems, Victoria, B.C.	5,375
Analysis of tidal and current data obtained in Harbours and Estuaries A. Harrison, Victoria, B.C.	3,876
Feasibility study on the international Ship-of-Opportunity program to obtain plankton and oceanographic data for long-range fisheries forecasts D.L. Mackas, Halifax, N.S.	540
Chemical support to the Institute of Ocean Sciences Seakem Oceanography Ltd., Sidney, B.C.	5,257

Investigation of cause of electrical failure of shore power connection from CSS Parizeau Case Existological Labs Ltd., Victoria, B.C.	2,296
Preparation of data and oceanographic diagrams C. Wallace, Sidney, B.C.	2,931
Collection and Analysis of beach sediments containing petroleum residues Seakem Oceanography Ltd., Victoria, B.C.	1,505
Biological and oceanographic research support to the Institute of Ocean Sciences University of Victoria, Victoria, B.C.	15,000
Study of Ice and water movements in Lancaster Sound and vicinity Arctic Sciences Ltd., Saanichton, B.C.	80,109
Oceanographic support to the Institute of Ocean Sciences Dobrocky Seatech Ltd., Victoria, B.C.	35,000
Development of Installation drawings and specifications for UNIVAC 1106 at the Institute of Ocean Sciences Pacific Rim Consultants Ltd., Vancouver, B.C.	6,400
Water properties sampling and measurement program aboard the CGS Vancouver at Ocean Station P Seakem Oceanography Ltd, Sidney, B.C.	49,986
Beaufort Sea wave climate study Seakem Oceanography Ltd., Sidney, B.C.	2,588
Radar tracking of ice in the Barrow Strait region of Parry Channel, N.W.T. Seakem Oceanography Ltd., Sidney, B.C.	42,142
Oceanic water properties sampling and measurements aboard CGS Quadra and chemical analysis Seakem Oceanography Ltd, Sidney, B.C.	67,000
Design and operation of the lead-210 tracer experiment under the Controlled Ecosystem Pollution Experiment University of B.C., Vancouver, B.C.	3,370
Collection and supply of hydrographic field data for correcting and up-dating navigational charts and sailing directions I.J. Campbell, Sidney, B.C.	12,620
Reduction and plotting of Knight Inlet oceanographic data Seakem Oceanography Ltd., Sidney, B.C.	16,000

Oceanographic Support for current, tide and depth surveys and tide gauge servicing in Knight Inlet C.R. Charters Ltd., Nanaimo, B.C.	14,000
Deployment and logistics planning and coordination for Global Atmospheric Research Program, (GARP) First GARP Global Experiment. Beak Consultants Ltd., Vancouver, B.C.	99,819
Oceanographic support to place instrument moorings in Knight Inlet Dobrocky Seatech Ltd., Victoria, B.C.	12,615
Data preparation and drafting for oceanographic data collected in Johnstone Strait during 1976 and 1977 cruises E.C. Luscombe, Sidney, B.C.	6,000
Preparation of check standards for the analysis of water samples for nutrients, alkalinity, trace metals and hydrocarbons, including preparation of calibration graphs, establishment of procedures, flow of work and times for analysis. L. Barry, Victoria, B.C.	3,015
Preparation of maps, graphs and drawings for report on the Environmental Assessment of Offshore drilling in Lancaster Sound Custom Drafting, Victoria, B.C.	13,410
Design of turbulence measuring equipment mount to Pisces IV Stockdale and Associates, Victoria, B.C.	2,500
Sediment and oligochaete sample collection from the Fraser River P. Chapman, Victoria, B.C.	500
Photogrammetric reduction of aerial photographs in support of the aerial hydrography project University of New Brunswick, Fredericton, N.B.	4,000
Development and fabrication of communication buoys capable of giving positional data via random access memory system communication with nimbus satellites Polar Research Laboratory Inc., Santa Barbara, Calif. U.S.A.	84,564
Study of the behaviour of the emulsified oil in sea water Seakem Oceanography Ltd., Sidney, B.C.	27,622
Collating and plotting of oceanographic data C. Wallace, Sidney, B.C.	3,000
Deep Sea recovery project of radioactive materials under the auspices of the United States Environmental Protection Agency Hyco Subsea Ltd., Vancouver, B.C.	42,000
Development and design of electronic components for a data acquisition system to be used in Pisces IV submersible Novatech Designs Ltd., Victoria, B.C.	3,199

Study to determine oceanographic energy budget for Ocean Weather Station P P.R. LaCroix, Victoria, B.C.	3,600
Identification and sorting of British Columbia marine zooplankton samples H.A. Sefton, Victoria, B.C.	4,015
Oceanographic Support for a study in Knight Inlet Ivanhoe Enterprises Ltd., Vancouver, B.C.	58,167
Development of software drivers for HP9825 to HP2100 interface Apocalypse Enterprises Ltd., Victoria, B.C.	1,125
Laboratory study of behaviour of oil and gas particles in salt water relating to deep oil well blowouts University of Calgary, Calgary Alta.	64,935
Vessel support for oceanographic activities by the Institute of Ocean Sciences Bastion City Charters Ltd., Nanaimo, B.C.	10,000
Determination of well-posed boundary conditions for numerical tidal models F. Milinazzo, Victoria, B.C.	2,000
Study of chlorophyll concentrations in sea water R.A. Neville, Sidney, B.C.	8,490
Development of computer programs for ocean mixing Apocalypse Enterprises Ltd., Victoria, B.C.	19,496
Development of computer programs for remote sensing Apocalypse Enterprises Ltd., Victoria, B.C.	12,990
Study of trace metals in B.C. coastal waters Seakem Oceanography Ltd., Sidney, B.C.	37,653
Analysis of tides at permanent tidal stations in British Columbia coastal waters Dobrocky Seatech Ltd., Victoria, B.C.	9,960
Identification and enumeration of benthic marine animals Dobrocky Seatech Ltd., Victoria, B.C.	3,455
Development and documentation of air droppable random access memory buoys in the Beaufort Sea Norcor Ltd., Yellowknife N.W.T.	22,000

Deployment of Beaufort sea drift buoys Arctic Sciences Ltd., Victoria, B.C.		4,000
		979,425
Unsolicited proposals		714,318
Ocean Dumping		79,762
		1,773,505
University	87,305	
Individuals	80,741	
	168,046	

Industry - 1,605,459

Unsolicited Proposals

Development of a direction indicating system for current meters using acoustics Caulfield-Liron Consultants Ltd., Edmonton, Alta.	222,640
Physical Oceanographic study in the Kitimat area Dobrocky Seatech Ltd., Victoria, B.C.	491,678
	714,318

Ocean Dumping

Research and record activities relating to ocean dumping on the west coast K.E. Conlon, Victoria, B.C.	6,192
Variability in analytical results on dredged spoils and marine sediments in connection with the validity of presently prescribed criteria Chemex Labs Ltd., N. Vancouver, B.C.	9,485
Analytical support for a study of mercury biotransformation in anoxic estuarine sediments Willis, Cunliffe Tait and Co. Ltd., Victoria, B.C.	3,990
Oxygen budget studies in Alberni Inlet Dobrocky Seatech Ltd., Victoria, B.C.	21,393
Collection and analysis of seawater and undisturbed sediment cores in Alberni Inlet Chemex Labs Ltd., North Vancouver, B.C.	5,415
Marine biological sampling and observations of temporal changes in benthic communities and benthic respiration at a dumpsite in Port Alberni Beak Consultants Ltd., Vancouver, B.C.	27,085
Chemical and physical analysis of samples containing wood debris (ocean dumping) obtained in Alberni Inlet Econotech Services Ltd., New Westminster, B.C.	6,202

PUBLICATIONS

Institute of Ocean Sciences, Patricia Bay, 1976 Annual Report

PACIFIC MARINE SCIENCE REPORTS

PMSR 77-1

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 74, 18 June-9 August 1976.

PMSR 77-2

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 75, 30 July-16 September 1976.

PMSR 77-3

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 76, 10 September-27 October 1976.

PMSR 77-4

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 77, 22 October-8 December 1976.

PMSR 77-5

Cretney, W.J., W.K. Johnson, C.S. Wong — Trace analysis of oil in sea water by fluorescence spectroscopy.

PMSR 77-6

Macdonald, R.W., C.W. Wong — The interaction of chlorine and seawater.

PMSR 77-7

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 78, 3 December 1976 - 13 January 1977.

PMSR 77-8

Bell, W.H. — The use of extruded plastic fairing for a subsurface mooring.

PMSR 77-9

MacNeill, Margaret — A study of anomalous salinity and oxygen values in the deep water at Ocean Station P from 1960-1976.

PMSR 77-10

Foreman, M.G.G. — Manual for tidal heights analysis and prediction.

PMSR 77-11

Henry, R.F., M.G.G.Foreman — Numerical model studies of semi-diurnal tides in the Southern Beaufort Sea.

PMSR 77-12

Bell, W.H. — Static analysis of single-point moorings.

PMSR 77-13

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 79, 7 January-17 February 1977.

PMSR 77-14

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 80, 11 February-31 March 1977.

PMSR 77-15

Oliver, B.M., J.F.R.Gower — Airborne measurements of horizontal wind.

PMSR 77-16

Bell, W.H. — An In Situ drag coefficient determination for an Aanderaa thermistor chain.

PMSR 77-17

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50 N,145 W) volume 81, 25 March-12 May 1977.

PMSR 77-18

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 82, 6 May-23 June 1977.

PMSR 77-19

Mortimer, A., R. Schoenrank — A loran-C calibration, the west Canadian chain latticing and guidance systems for inshore operations.

PMSR 77-20

Frozen Sea Research Group — Oceanographic data Crozier and Pullen Straits, N.W.T. March-April 1977.

PMSR 77-21

Webster, I., D.M. Farmer — Analysis of lighthouse station temperature and salinity data - Phase II.

PMSR 77-22

Macdonald, R.W., C.S.Wong — The distribution of mercury in Howe Sound sediments.

PMSR 77-23

Frozen Sea Research Group — Oceanographic data report d'Iberville Fiord Ellesmere Island, N.W.T. March, 1977.

PMSR 77-24

Seakem Oceanography Ltd. — Oceanographic observations at Ocean Station P (50°N,145°W) volume 83, 17 June-3 August 1977.

CONTRACTOR REPORT SERIES
(Started 1977)

CRS 77-1

CTF Systems Inc. — Final report of a feasibility study on an underwater current meter platform.

CRS 77-2

Ward, John G., C.Eric Tull — Scientific studies to be conducted in response to an oil spill in the Beaufort Sea.

CRS 77-3

Webster, Ian — A physical oceanographic study of Haro Strait: a data summary and preliminary analysis.

CRS 77-4

Marko, J.R. — A satellite-based study of sea ice dynamics in the central Canadian Arctic Archipelago.

CRS 77-5

Associated Engineering Services Ltd. — Analysis of lighthouse oceanographic data - Phase III.

CRS 77-6

Gavin, A.M., V.I.Macdonald, Beak Consultants Ltd. — Annotated bibliography of the polychaeta of the Pacific Northwest.

DATA RECORD OF CURRENT OBSERVATIONS

Huggett, W.S., J.F. Bath, A. Douglas	Data record of current observations volume XV, Juan de Fuca Strait 1973.
Huggett, W.S., M.J.Woodward, A.N. Douglas	Data record of current observations volume XVI, Beaufort Sea 1974 to 1976.

INSTITUTE OF OCEAN SCIENCES NOTES
(Started 1977)

IOS Note - 1

Wong, C.S., J.A.J.Thompson, R.W. Macdonald	Chemical studies on mercury in Howe Sound and heavy metals at Point Grey Dump site, 1976-77.

IOS Note - 2

Lee, A.Y.P. (Editor)	Physical limnology of Babine Lake data summary 1972-1974, Part 1.

IOS Note - 2

Lee, A.Y.P. (Editor)	Physical limnology of Babine Lake data summary 1972-1974, Part 2.

IOS Note - 3

Walker, E.R.	Aspects of oceanography in the archipelago.

OTHER PUBLICATIONS - 1977

Blood, D.A., 1977. Birds and Marine Mammals - The Beaufort Sea and the search for oil. Edited by Brian D. Smiley. Victoria, Beaufort Sea Project Overview Report.

Brinkhurst, R.O., 1977. Heterospecific groups. Bioscience, Nov., p.713.

Brinkhurst, R.O., 1977. Oligochaeta in limnofauna Europa. Edited by J. Illies. The Hague, Swets & Zeitlinger (in press).

Brinkhurst, R.O., 1977. Pelagic Ecosystem Prediction Project. Proceedings of a workshop on proposed Ship-of-Opportunity Program, Feb. 18-19, 1977. Institute of Ocean Sciences, Patricia Bay, Sidney, B.C. 56 pp.

Brinkhurst, R.O., 1977. Report on Ocean Dumping R & D. Canada. Department of Fisheries and the Environment, Pacific Region.

Crean, P.B., 1976. Numerical model studies of the tides between Vancouver Island and the mainland coast. J. Fish. Res. Bd. Can. 33: 2340-2344.

Denman, K.L., 1977. Short term variability in vertical chlorophyll structure. Limnology & Oceanography 22: 434-441.

Denman, K.L., B. Irwin & T. Platt, 1977. Phytoplankton productivity experiments and nutrient measurements at the edge of the Nova Scotia continental shelf between June 27 and July 12, 1976. Canada. Department of Fisheries and the Environment. Fisheries and Marine Service Technical Report 708. 205 pp.

Denman, K.L., A. Okubo & T. Platt, 1977. The chlorophyll fluctuation spectrum in the sea. Limnology & Oceanography 22: 1033-1038.

Denman, K.L. & T. Platt, 1977. Biological prediction in the sea. IN: Modelling and Prediction of the Upper Layers of the Ocean. Editor, E.B. Kraus, P. Pergamon, Oxford. pp. 251-260.

Denman, K.L, P.E. Vandall, A.W. Herman & F. Jordan, 1977. Shipboard observations for the chlorophyll remote sensing experiment off Yarmouth, Nova Scotia, August 1975. Canada. Department of Fisheries and the Environment. Fisheries and Marine Service Technical Report 706. 35 pp.

Freeland, H.J., 1977. Variations in the Earth's orbit; Pacemaker of the Ice Ages? Science 198: 528-529.

Gardner, G.A., 1977. Analysis of zooplankton population fluctuations in the Strait of Georgia, British Columbia. J. Fish Res. Bd. Can. 34: 1196-1206.

Gower, J.F.R., 1977. The computation of ocean wave heights from GEOS-3 satellite radar altimeter data. IN: American Institute of Aeronautics and Astronautics Conference on Satellite Applications to Marine Technology. New Orleans, November 1977. (in press)

Gower, J.F.R., 1977. Microwave sensing of sea surface wave patterns. IN: 4th Canadian Symposium on Remote Sensing, Quebec City, May 1977. pp. 395-406.

Gower, J.F.R. & R.A. Neville, 1977. A method for the remote measurement of the vertical distribution of phytoplankton in sea water. IN: 4th Canadian Symposium on Remote Sensing, Quebec City, May 1977. pp. 532-542.

Grasty, R.L., J.F.R. Gower & B.M. Oliver, 1977. Inertial Navigation for flight path recovery. Geological Survey of Canada, Paper 76030. 12 pp.

Greisman, P. & R.G. Ingram, 1977. Nutrient distribution in the St. Lawrence Estuary. J. Fish. Res. Bd. Can. 34: 2117-2123.

Herman, A.W. & K.L. Denman, 1977. Rapid underway profiling of chlorophyll with an in situ fluorometer mounted on a 'Batfish' vehicle. Deep Sea Research 24: 385-397.

Kroopnick, P.M., S.V. Margolis & C.S. Wong, 1977. $\delta^{13}C$ variations in marine carbonate sediments as indicators of the CO_2 balance between the atmosphere and the oceans. IN: The fate of Fossil Fuel CO_2 in the Oceans. Edited by N.R. Anderson & A. Malahoff. Plenum Pub. Corp, New York. pp. 295-321.

Macdonald, R.W., 1977. The interaction of chlorine and seawater, with special reference to the four liquid chlorine tank cars lost in British Columbia coastal waters. Journal of Hazardous Materials 2(1): 51-75.

Marko, J. & R.E. Thomson, 1977. Rectilinear Leads and Internal Motions in the Ice Pack of the Western Arctic Ocean. K.J. Geophysical Research 82: 979-987.

Matsumoto, E. & C.S. Wong, 1977. The distribution of suspended particles in the Southern Beaufort Sea. J. Oceanogr. Soc. of Japan, 33: 227-233.

Matsumoto, E. & C.W. Wong, 1977. Heavy metal sedimentation in Saanich Inlet measured with 210 Pb technique. J. Geophysical Research 82: 5477-5482.

Milne, A.R., R.H. Herlinveaux & G.R. Wilton, 1977. A field study on permeability of multiyear ice to seawater with implications of its permeability to oil. Canada. Environmental Protection Service. Technology Development Report EPS-4-ED-77-11. 33 pp.

Neville, R.A. & J.F.R. Gower, 1977. Passive remote sensing of phytoplankton via chlorophyll and fluorescence. J. Geophysical Res. 82: 3487-3493.

Oliver, B.M. & J.F.R. Gower, 1977. Use of an inertial navigation system for accurate track recovery and coastal oceanographic measurements. IN: Proceedings of the Eleventh International Symposium on Remote Sensing of Environment, Environmental Research Institute of Michigan, Ann Arbor, Michigan, April 25-29, 1977. pp. 1399-1413.

Pararas-Carayannis, G. & S.O. Wigen, 1977. Philippine earthquake and tsunami of August 17, 1976. IUGG Tsunami Symposium of March 23-26, 1977. (in press).

Platt, T. & K. Denman, 1977. Biological prediction in pelagic marine ecosystems. IN; Proceedings of the ONR Symposium on Sound Scattering in the Oceans. Editors, Neil R. Anderson & Bernard J. Zahuranec. Plenum Press, Oxford. pp. 803-809.

Platt, T. & K.L. Denman, 1977. Organization in the pelagic ecosystem. Helgolander Wissenschaftliche Meersuntersuchungen 30: 575-581.

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PERMANENT STAFF 1977

DIRECTOR GENERAL

Stewart, R.W.; B.Sc., M.Sc., (Queen's), Ph.D. (Cantab), FRSC, FRS, D.Sc. (McGill), LL.D. (Dalhousie).

ASSISTANT TO DIRECTOR GENERAL

Cornford, A.B.; B.Sc. (McMaster), Ph.D. (Brit.Col.)

MANAGEMENT SERVICES DIVISION

Todd, N.A.; B.S. (Glasgow), M.A. (Carleton) - Chief of Division

Aanhout, D.L.v.
*Aavik, J.F.
Clarke, B.E.
Coldwell, J.H.
Cotter, M.L.
Craton, M.I.K.
Crouch, R.W.
Curtis, J.N.
Deane, G.J.
Doyle, D.A.
Drysdale, A.E.
Firth, C.
*Foote, S.B.
*Galibois, S.
Hall, E.J.
*Hogg, W. (deceased)
*Jensen, S.M.
Jones, K.M.G.
Kwiatkowski, B.S.
Lapp, B.I.; B.A. (Victoria)
Lohrmann, B.A.; B.Sc., M.Sc. (Guelph)
McKenzie, S.D.
*Martyn, B.T.
Miles, M.L.
Parsons, J.E.
Peirson, E.
Powers, M.A.
Reinstein, H.G.
Sabourin, J.T.
Smith, G.R.; B.A.Sc.(ME) (Brit.Col.), P.Eng.
Smith, R.M.
Thomas, C.D.
Thomson, L.S.C.; B.A. (Saskatchewan), B.L.S. (Brit.Col.)
van Dusen, T.S.
Wakefield, L.M.

*Left during 1977

COMPUTING SERVICES

Butcher, J.W.; B.Sc.(Victoria), M.Sc. (Toronto)
Douglas, A.N.; B.Sc.(Victoria)
Foreman, M.G.; B.Sc. (Queen's), M.Sc. (Victoria)
Johns, R.E.; B.Sc. (Victoria), M.Sc. (Brit.Col.)
Page, J.S.; B.Sc. (Brit.Col.)
Richards, P.J.; B.Sc. (Brit.Col.)
Smith, D.B.: B.Sc. (Victoria)
Teng, K.; B.A.Sc., M.A. (Brit.Col.)
Woollard, A.L.; B.Sc. (Victoria)
Woodward, M.E.; B.Sc. (Victoria) M.Sc. (Toronto)

HYDROGRAPHIC DIVISION

Bolton, M. - Regional Hydrographer

Ages, A.B.; B.A.Sc., M.A.Sc. (Brit.Col.), P.Eng.
Bell, R.D.
*Bennett, K.M.
Brown, R.E.
Browning, P.C.
Carracedo, C.
Chan, G.L.
Chivas, J.W.; Master, F.G.
Clark, D.J.
Coldham, F.A.
Cooke, R.A.
*Coulter, E.M.
Crawford, W.R.; B.Sc., M.A.Sc. (Waterloo), Ph.D. (Brit.Col.)
Crowley, J.V.
Crowther, W.S.
Curran, T.A.; B.A.Sc. (EE) (Brit.Col.), P.Eng.
Czotter, K.L.; Dip.BCIT
D'Aoust, A.J.
Dobson, D.C.
Dorosh, L.W.
Earl, E.L.P.
Eaton, G.H.; Dip.BCIT
Farmer, M.
Fisher, D.L.
Galloway, J.L.; B.A.Sc. (EE), M.A.Sc.(EE) (Brit.Col.),P.Eng.
Gregson, D.J.; Dip.BCIT
Harris, W.J.
Hermiston, F.V.
Hinds, E.W.; Dip.BCIT
Hohl, H.E.
Holman, K.R.
Huggett, W.S.; Master, F.G.
Johnson, B.A.; Dip.BCIT
Ma, A.C.; B.Sc. (Victoria)
Manley, A.B.; Dip.BCIT
May, R.I.D.; Dip.BCIT
Milner, P.R.; Dip.BCIT
Moody, A.E.
Mortimer, A.R.; Master, F.G.
Morton, P.A.; A.O.C.A.
Muse, R.A.; Trade Cert.CAF
*Nast, C.J.
Nielson, G.C.
O'Connor, A.D.; Master, H.T.(U.K.), 350 T
Osbourne, M.
Parker, R.N.S.
Patton, M.M.
Philp, A.R.
Pickell, L.M.
Pierce, R.A.
Popejoy, R.D.
Preece, M.L.; Dip.BCIT
*Prussner, L.E.; Dip.BCIT
Rapatz, W.J.; B.Sc.(Victoria)
Raymond, A.R.; Dip.(Algonquin College)
Richardson, G.E.
Ross, A.D.
Ryan, C.F.; Dip.RRE (England)
Said, N.A.
Sandilands, R.W.; Lt.RN (Retd.)
Sargent, E.D.; Dip.BCIT
Shoenrank, R.U.; B.Sc. (Victoria)
Smedley, A.J.; Lcdr.RCN (Ret'd.)
Smithers, F.R.
Soutar, T.J.; Dip.BCIT
Steeples, J.; Cert. Mech. Eng. (Edinburgh)
Stephenson, F.E.; B.Sc. (Victoria)
Tamasi, C.R.; Dip.BCIT

*Left during 1977

*Johnson, R.W.
Josephson, K.G.
Korhonen, R.K.
Kynoch, B.D.
Larkin, J.G.; B.Sc.(P.E.I.)
Loschiavo, R.; Dip.BCIT
Lusk, B.M.; 350 T
Lyon, A.G.
Lyons, W.J.L.; C.C. (Ont. Inst. Cartographers)
Wigen, S.O.; B.A.Sc. (Brit.Col.), P.Eng.
Wills, R.; Master, F.G.
Wood, D.J.; Dip.BCIT
Taylor, M.S.
Taylor, R.G.
Taylor, W.R.; Dip.RCC
Thompson, L.G.
Vosburgh, J.A.; Dip.(BCIT)
Wanamaker, J.G.; Dip.BCIT
Ward, M.M.; Dip.(BCIT)
Watt, B.M.
Watt, J.W.; B.A.Sc.(EE) (Brit.Col.), P.Eng.
Woods, M.V.; Dip.BCIT
Woodward, M.J.; B.Sc. (Victoria, M.Sc. (Toronto)

OCEAN PHYSICS DIVISION

Nasmyth, P.W.; B.A.Sc., M.A., Ph.D. (Brit.Col.) - Chief of Division

Bell, W.H.; B.A.Sc. (Brit.Col.), M.Sc. (Hawaii), P.Eng.
Bigham, R.H.
Chase, G.W.; Dip.BCIT
Crean, P.B.; B.Sc. (Dublin), M.A.Sc.(Toronto), Ph.D. (Liverpool)
de Jong, C.
Farmer, D.M.; B.Com., M.Sc.(McGill), Ph.D. (Brit.Col.)
Freeland, H.J.
Gargett, A.E.; B.Sc. (Manitoba), Ph.D. (Brit.Col.)
Garrett, J.F.; B.A. (Harvard), Ph.D. (Brit.Col.)
Giovando, L.F.; B.A., M.A., Ph.D. (Brit.Col.)
Gower, J.F.R.; B.A., M.A., Ph.D. (Cantab)
Henry, R.F.; B.Sc. (Edinburgh), Ph.D. (Cantab)
Herlinveaux, R.H.
Kamitakahara, G.R.; B.Sc. (Toronto)
Koppel, A.W.
Kimber, P.M.
Kuwahara, L.S.C.; B.Sc. (Brit.Col.)
Lake, R.A.; B.Sc. (Brit.Col.), M.Sc. (Washington)
Lewis, E.L.; B.Sc., M.Sc., Ph.D. (London)
Love, J.
McNeill, J.M.
Meikle, J.H.
Milne, A.R.; B.A.Sc. (Toronto), M.Sc. (McGill)
Minkley, B.G.; Dip.BCIT
Miyaki, M.; B.S.(EE) (Drexel), M.S., Ph.D. (Washington)
Moorhouse, S.W.
Perkin, R.G.; B.A.Sc., M.Sc. (Brit.Col.)
Richards, D.L.
Sieberg, D.G.; Dip.VVI
Smiley, B.D.; B.Sc., M.Sc. (Alberta)
Spearing, L.A.F.; B.Sc. (Brit.Col.)
Stickland, J.A.
Stucchi, D.J.; B.A.Sc. (York), M.Sc. (Dalhousie)
Sudar, R.B.; B.A.Sc. (Toronto)
Tabata, S.; B.A., M.A. (Brit.Col.), D.Sc. (Tokyo)
Teichrob, R.C.; Dip.BCIT
Thomson, R.E.; B.Sc., Ph.D. (Brit.Col.)
Walker, E.R.; B.Sc. (Manitoba), M.A. (Toronto), Ph.D. (McGill)
Wallace, J.S.

*Left during 1977

OCEAN ECOLOGY LABORATORY

Brinkhurst, R.O.; D.Sc. (London) - Head

Austin, M.J.; B.Sc. (Brit.Col.)
Denman, K.L.; B.Sc. (Calgary), Ph.D. (Brit. Col.)

OCEAN CHEMISTRY DIVISION

Wong, C.S.; B.Sc., M.Sc. (Hong Kong), Ph.D. (Scripps), Dip.Mar.Sc. (UNESCO), MCIC, FRIC - Chief of Division

Bellegay, R.D.; Dip.NAIT, Ass.Deg. in Oceanography (Shoreline Community College, Seattle)
Cretney, W.J.; B.Sc., Ph.D. (Brit.Col.)
*Jackson, C.M.; B.Sc. (Victoria)
Johnson, W.K.; Dip.BCIT
Macdonald, D.M.; B.A.Sc. (Brit.Col.)
Macdonald, R.W.; B.Sc., Ph.D. (Dalhousie)
McLaughlin, F.; B.Sc. (Victoria)
Munro, P.; B.Sc. (Queen's)
Paton, D.; B.Sc. (Brit.Col.)
Thompson, J.A.J.; B.Sc. (McMaster), Ph.D. (Alberta)

SHIP DIVISION

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Green, F.S.	Master Mariner; Assistant Marine Superintendent (Deck)
*Marr, D.	1st Class Marine Engineer, Fellow Institute of Marine Engineers; Assistant Marine Superintendent (Engineering)
Parkinson, R.	Engineer 1st Class Combined; Chief Engineer
Keene, R.W.	Master, F.G. (X); Relief Master
Henderson, J.D.	Engineer 2nd Class Steam; Depot Supervisor
Chan, C.C.	Engineer 1st Class Motor; Relief Engineer

CSS PARIZEAU

Chamberlain, A.G.	Master, F.G.; Master
Fisher, E.G.	Master, F.G.; 1st Officer
Christie, J.N.	Radio Certificate; W/O
Clarke, L.E.	Supply Officer
Kyle, R.G.	Engineer 2nd Class Motor; Senior Engineer
Orr-Hood, J.	Engineer 4th Class Motor; 2nd Engineer

*Left during 1977

CSS WM.J.STEWART

Sjoholm, K.J.	Master, F.G.; Master
Easson, R.J.	Master, F.G.; 1st Officer
Palmer, S.	Supply Officer
Gibson, R.B.	Engineer 3rd Class Steam; Senior Engineer
Conway, A.	Engineer 4th Class Combined; 2nd Engineer

CSS VECTOR

Marston, J.C.	Master, F.G.; Master
Bishop, S.O.	Mate H.T.; 1st Officer
Purdon, D.	Mate, H.T.; 2nd Officer
Peet, J.	Engineer 3rd Class Motor; Chief Enginer
Pearson, R.	Engineer 3rd Class Motor; 1st Engineer
Knoblauch, I.	Engineer 4th Class Motor; 2nd Engineer

CSS RICHARDSON

Wheeler, M.G.	Master, 350 T; Master
Henderson, J.N.	Engineer 4th Class Motor; Chief Engineer

MV RADIUM EXPRESS

O'Sullivan, J.	Master
Butler, W.	Chief Engineer

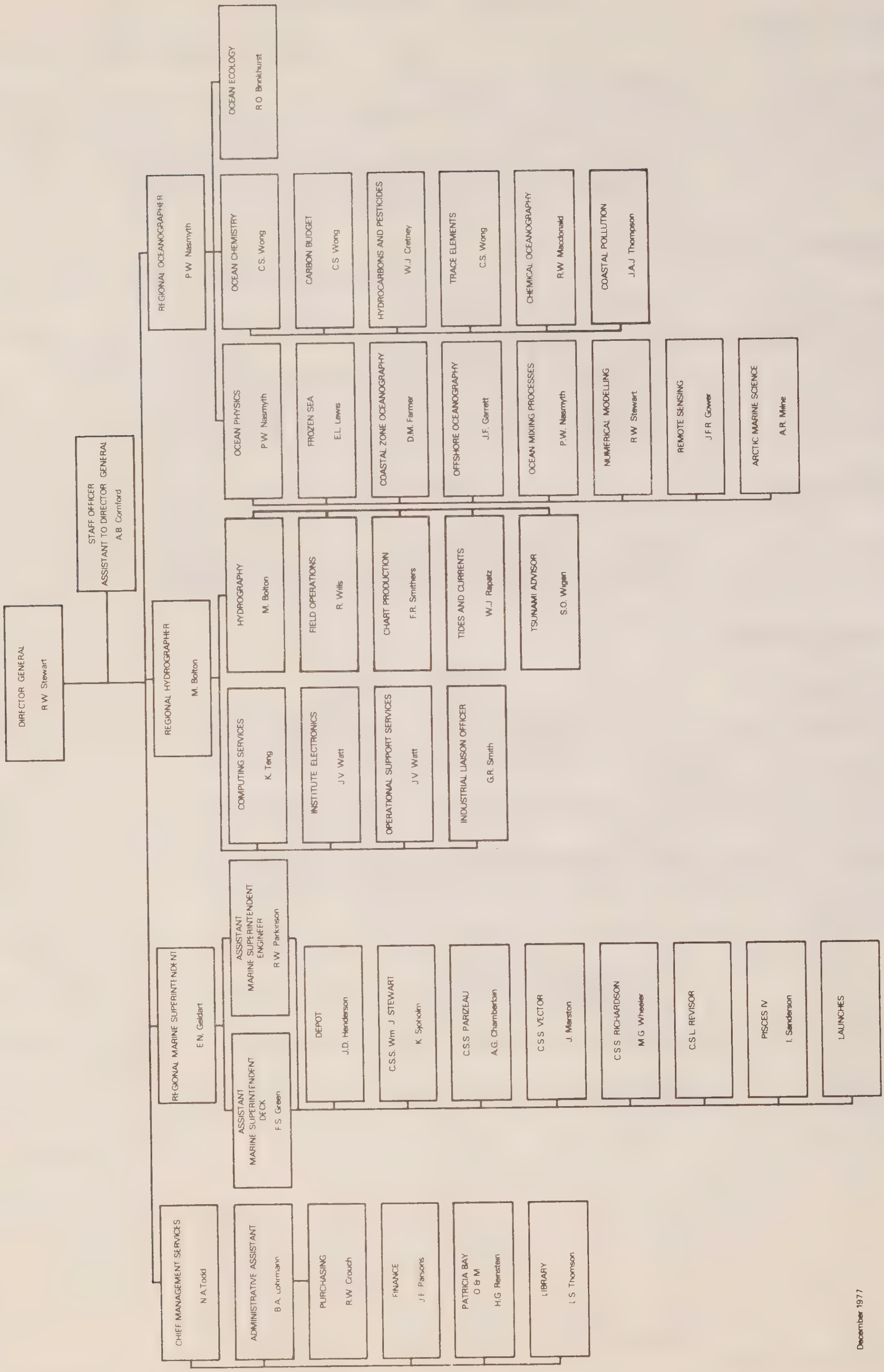
MV PANDORA II (Charter)

Jones, R.	Master
Tuck, C.	Chief Engineer

PISCES IV

*Meek, G.R.	Operations Officer
Sanderson, I.	Chief Pilot
Chambers, F.	Pilot
Taylor, R.H.	Pilot
Jacobson, R.	Pilot
Gaudreault, J.	Pilot
Grant, D.	Pilot

*Left during 1977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STAFF OFFICER
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R.W. Stewart
REMOTE SENSING
J.F.R. Gower
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A.R. Milne
REGIONAL HYDROGRAPHER
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HYDROGRAPHY
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K. Teng
INSTITUTE ELECTRONICS
J.V. Watt
OPERATIONAL SUPPORT SERVICES
J.V. Watt
INDUSTRIAL LIAISON OFFICER
G.R. Smith
REGIONAL MARINE SUPERINTENDENT
E.N. Geldart
ASSISTANT
MARINE SUPERINTENDENT
ENGINEER
R.W. Parkinson
ASSISTANT
MARINE SUPERINTENDENT
DECK
F.S. Green
DEPOT
J.D. Henderson
C.S.S. Wm. J. STEWART
K. Sjoholm
C.S.S. PARIZEAU
A.G. Chamberlain
C.S.S. VECTOR
J. Marston
C.S.S. RICHARDSON
M.G. Wheeler
C.S.L. REVISOR
PISCES IV
I. Sanderson
LAUNCHES
CHIEF MANAGEMENT SERVICES
N.A. Todd
ADMINISTRATIVE ASSISTANT
B.A. Lohmann
PURCHASING
R.W. Crouch
FINANCE
J.E. Parsons
PATRICIA BAY
O & M
H.G. Reinstein
LIBRARY
I.S. Thomson
December 1977